Masters of Health Sciences

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Postgraduate Simulation within a Hospital Setting, with a focus on Crisis Resource Management and Team Training, in Acute Care Paediatrics:

Where are we and where should we be?

Acknowledgments

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Preface

I make no apology for the detailed introduction. I have deliberately provided a significant contextual background to this thesis that has provided me with the opportunity to fulfill two personal aims;

- An excuse to reflect on and integrate my thoughts regarding some of the theoretical, educational and clinical aspects of simulation within healthcare.
- The development of my theoretical and practical expertise within the area of educational research.

I have absolutely loved having the excuse and opportunity to immerse myself in an area that I had the privilege of being introduced to in 2008. At times throughout this thesis I have taken the liberty of expressing my own view, an opinion that I hope is grounded in an understanding of the underlying theories as well as extensive clinical and simulation experience. This work has developed that opinion and I hope it has provided a solid foundation for my own future research.

I hope also that it will provide a conduit for collaboration with others in research that has as its focus the effective and efficient education of healthcare professionals for the sole purpose of improving our provision of healthcare. My philosophy can be summed up by the three quotes below:

"He who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may cast"

Leonardo Da Vinci

"The art of medicine was to be properly learned only from its practice and its exercise"

Thomas Sydenham

"Practice makes permanent"

Bobby Robson

Abbreviations and definitions

A/B	Antibiotics
ABP	Arterial Blood Pressure
Advocacy Inquiry	A feedback method published by the Center for Medical Simulation (Rudolph, Simon, Dufresne, & Raemer, 2006)
APLS	Advanced Paediatric Life Support (UK and Australasia),
ACC	Accident Compensation Corporation
APLS	Advanced Paediatric Life Support
BAT	Behavioural Assessment Tool
BP	Blood Pressure
BEME	Best Evidence Medical Education
CAIPE	Centre for the Advancement of Interprofessional Education
Closed Loop Communication	Receiver repeats back message for clarification and original sender confirms correct message received
Code	Respiratory or Cardiac Arrest
CDHB	Canterbury District Health Board
CRM	Crisis Resource Management
CIMS	Coordinated Incident Management System
CPAP	Continuous Positive Airway Pressure
CPR	Cardiopulmonary Resuscitation
CPT	Clinical Performance Tool
CVP	Central Venous Pressure
Dx	Diagnosis
ECG	Electrocardiograph
ECMO	ExtraCorporeal Membrane Oxygenation
EEG	Electroencephalograph
EKG	Electrocardiograph
EPLS	European Paediatric Life Support
ET	Endotracheal (Tube)

GBS	Group B Streptococci
HR	Heart Rate
ICP	Intracranial Pressure
ID	Identification
IHI	Institute for Healthcare Improvement
IPE	Interprofessional Education
IPL	Interprofessional Learning
ISBAR	Identification / Situation / Background / Assessment / Recommendation
IV	Intravenous
IVF	In Vitro Fertilisation
KUB	Kidney, Ureter and Bladder
Mcg	Micrograms
Mock Code	Simulated Respiratory or Cardiac Arrest
MHPTS	Mayo High Performance Teamwork Scale
NIBP	Non Invasive Blood Pressure
NEOB	New England Organ Bank
NLS	Neonatal Life Support
NRP	Neonatal Resuscitation Program (USA)
NS	Normal Saline
NZ	New Zealand
NMDHB	Nelson and Marlborough District Health Board
NICU	Neonatal Intensive Care Unit
NKA	No Known Allergies
NBM	Nil By Mouth
Non-Technical	Social and cognitive skills (eg CRM) that include decision making, communication and situation awareness
NPO	Nil Per Oral
PALS	Paediatric Advanced Life Support (USA)
PAP	Pulmonary Arterial Pressure

PERCS	Program to Enhance Relational and Communication Skills
PICU	Paediatric Intensive Care Unit
PIH	Pregnancy Induced Hypertension
OR	Operating Room
OSCAR Tool	Observations Skill-based Clinical Assessment for Resuscitation
OTAS	Observational Teamwork Assessment for Surgery
HDC	Health and Disability Commissioner
HQSC	Health Quality and Safety Commission
RACP	Royal Australasian College of Physicians
RCPCH	Royal College of Paediatrics and Child Health
RR	Respiratory Rate
SCDHB	South Canterbury District Health Board
SDHB	Southern District Health Board
SIMV	Synchronised Intermittent Mandatory Ventilation
STAT	Solutions Training and Teamwork
Sx	Signs
Technical	Specific Clinical and Procedural Skills
TRACS	Tool for Rapid Advanced Cockpit Simulation
TEAM Tool	Team Emergency Assessment Measure
WCDHB	West Coast District Health Board
UK	United Kingdom

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Introduction

The intention of this thesis is to present information relating to the use of interprofessional simulation team training or crisis resource management in the area of postgraduate training for those health professionals involved in acute paediatric care. The initial stimuli for this review came from two areas; an increasing understanding of the challenges of providing paediatric intensive care within the Canterbury District Health Board (CDHB) as well as the wider context of the South Island of New Zealand and a belief that appropriately targeted interprofessional simulation education could contribute to improved organizational culture and improved patient care. The final trigger can be considered as the death of a young infant who required paediatric intensive care. Her death may not have been avoidable but as a clinician involved with the case I, and many others, were moved to consider aspects of our healthcare in which improvements could be made. I believe that the efficient embedding of effective simulation clinical training is a core part of providing improvements in healthcare for the following reasons that will be elaborated on within this thesis:

- Continued quality improvement in the knowledge, skills and service-based application requires a recognition that it is not about the provision of service being in conflict with attendance at educational sessions but about both being necessary and complementary.
- Simulation of clinical scenarios provides the opportunity for regular practice of the core skills of individuals such that they become as automatic as driving a car, and as a result do not require significant cognitive energy input.
- Simulation of clinical scenarios also provides the opportunity to practice those skills that are vital in specific situations but are rarely encountered within the workplace. It begins an individual’s cognitive preparation for the rare event.
- Regular department and team simulation enables the development of communication skills, with standardisation of communication processes and a common language, to enhance the efficiency and minimize the effect of bias, assumptions and misunderstandings.

- The skills of 'teaming' are modeled within the clinical simulation and within the workplace by faculty leading simulation.
- The combination of clinical simulation with expert debriefing provides an opportunity to discuss processes that need improvement and the running of simulation within the workplace may highlight previously unrecognized latent errors within the system

The evidence behind these opinions will be reviewed under the following headings:

- Chapter 1: Providing a Clinical Context
- Chapter 2: Teamwork, Teaming and Crisis resource management
- Chapter 3: Relevant Educational Theory
- Chapter 4: Simulation within Healthcare
- Chapter 5: Evaluating Educational Outcome
- Chapter 6: Research Methodology
- Chapter 7: Description of Methods
- Chapter 8: Results of Literature Review and Visits
- Chapter 9: Discussion
- Chapter 10: Conclusion
- Chapter 11: Reflecting on this work

The aim of this research was to examine the evidence for interprofessional crisis resource management (CRM) simulation training in paediatric clinical care. It is hoped that this will then inform the evidence-based development of a paediatric clinical simulation program (10.2). The methods involved in this research are divided into two sections to reflect the two main areas of investigation that were employed, notably:

- Review of relevant literature. This includes a review of literature that has relevance to team training or CRM training in the context of paediatric acute clinical crises.
- Observation of internationally recognized Simulation Courses aimed at those healthcare workers involved in the provision of acute paediatric care

The results will be presented using themed headings and the conclusion aims to summarise the information gathered and to suggest a sustainable efficient and effective way in which to embed Paediatric Interprofessional Clinical Simulation within the CDHB and possibly the South Island.

In order to provide a background to the clinical context I will begin with a short summary of the provision of Paediatric Intensive Care within CDHB and the South Island of New Zealand.

1 Providing a Clinical Context

The aim of this chapter is to provide an introduction to important areas that allow contextualization of subsequent background chapters as well as this area of research. It will begin by describing aspects of healthcare relevant to the provision of Paediatric Intensive Care within the South Island, and an overview of important areas in paediatric mortality and morbidity. This will be followed by a short introduction to the area of patient safety and the contribution of human factors to the safety of our patients.

1.1 Paediatric Intensive Care within the South Island

The District Health Boards (DHBs) that serve Christchurch, Canterbury, West Coast and the other areas of the South Island as well as their populations are shown in Table 1 below (www.stats.govt.nz)

Table 1 DHBs serving Canterbury, West Coast and other areas of the South Island with their 2013 population

Area	Name of DHB	2013 Population
Christchurch City	Canterbury (CDHB)	341 469
Canterbury	Canterbury (CDHB)	539 433
Timaru District	South Canterbury (SCDHB)	43 929
West Coast	West Coast (WCDHB)	32 148
Nelson Region	Nelson and Marlborough (NMDHB)	46 437
Marlborough Region	Nelson and Marlborough (NMDHB)	43 416
Otago	Southern (Southern DHB)	202 467
Southland	Southern (Southern DHB)	93 339
South Island Population		1004 397

Christchurch Hospital and Christchurch Women's Hospital are part of Canterbury District Health Board (CDHB), the largest DHB in the South Island, which has strong links with South Canterbury DHB and the West Coast DHB. CDHB does not have a Paediatric Intensive Care Unit (PICU). The only PICU in New Zealand is at Starship Hospital in Auckland on the North Island and children from the South Island that require paediatric intensive care can be transferred up to Auckland. Canterbury, Timaru, Dunedin and Invercargill all provide paediatric acute services with 24 hour paediatric cover although the exact nature of that cover varies. Canterbury is the only hospital in the South Island with 24 hours acute paediatric surgical cover and a paediatric high dependency unit (PHDU). It also has a separate clinical roster for neonatal intensive care services. Short-term intensive care is provided by the Adult Intensivists working alongside the paediatric and anaesthetic services with transfer to the PICU in the North Island if required (Starship Hospital).

It is useful to consider the Paediatric Intensive Care Services provided in other developed countries with which New Zealand has close relationships; in the United States of America in 2001 there were 349 PICUs with 3, 899 beds (Randolph, Gonzales, Cortellini, & Yeh, 2004) that can be considered in comparison to a *total* population of approximately 285 million. This equates to 1 PICU for every 820 000 *total* population or 1 PICU bed for every 73, 000 *total* population. In the United Kingdom data is collected by the Paediatric Intensive Care Audit Network and their 2009 report (NET, 2009) was from 28 PICUs between January 2006 and December 2008 when the *total* population of the UK was approximately 61 000 000. This equates to 1 PICU per 2 200 000 *total* population (almost 3 x the population per PICU than in the USA).

The health system in New Zealand is largely publicly funded and more aligned with the United Kingdom model than the United States. In England 1.4 per 100 000 children are admitted to a PICU bed per year (NET, 2009) and this would provide an estimate of 15 children per year in the South Island or just over 1 child per month. The actual number of children admitted to Starship Paediatric Intensive Care Unit from the South Island in 2014 was 27 (personal communication) which is the equivalent of slightly more than 2 children per month but some of these were planned re-admissions for cardiac surgery for example. This number is not enough to justify a fully staffed PICU in the South Island for reasons that include financial cost as well as maintenance of staff expertise in specialist paediatric intensive care skills. However, there is still a duty of care to the children that do require Paediatric Intensive Care within the South Island and a different model of care must be employed. This involves the collaborative working of specialist teams such as general paediatricians, neonatologists, emergency physicians and surgeons and the preparation of these teams with efficient effective regular sustainable clinical simulation. The aim is to provide short term care along a paediatric intensive care continuum prior to transfer of the child to Auckland, Clinical Simulation is used to complement work experience to maintain core paediatric resuscitation skills as well as developing the short term paediatric intensive care skills that may be required. The paediatric Intensivists from Starship have produced a report in collaboration with the General Paediatricians in Christchurch that aims to outline some of the challenges and possible solutions (personal communication) and have also developed an outreach service for paediatric simulation training.

1.2 Paediatric Mortality and Morbidity

Paediatric Mortality Data in New Zealand is collected through the Perinatal and Maternal Mortality Committee (PMMRC) and Child and Youth Mortality Review Committee (CYMRC) of the Health Quality and Safety Commission (HQSC). The PMMRC collects data relating to neonatal deaths from 20 weeks gestation until 28 days of age and the CYMRC collects data on deaths from 28 days of age until 24 years. 488 children and young adults died in 2014 of which 39% were associated with a medical diagnosis and 28% with unintentional injury. When considering children below 15 years of age the highest mortality rate was in infancy (< 1 year of age). The total mortality rate in infancy (*excluding the neonatal period*) between 2010 and 2014 exceeds 1 per 1000 live births when medical and unintentional injury is included. The neonatal mortality rate is 1 per 200 births (from 20 weeks gestation to 28 days following birth) when stillbirths are included. There were over 6000 live births in Canterbury in 2014, which means that more than 6 children will have died ***after*** the neonatal period. It is not immediately clear whether any of these deaths could have been prevented. It was also previously mentioned that in 2014 there were 27 children admitted to Starship PICU in Auckland from the South Island, because of a need for paediatric intensive care. The experience of healthcare staff outside of a paediatric intensive care unit caring for critically ill children is therefore limited. Internationally the outcome from paediatric arrest remains poor (de Mos, van Litsenburg, McCrindle, Bohn, & Parshuram, 2006; Moler et al., 2009) and this risk is known to be increased is children that have had surgery for congenital heart disease (Miyazaki et al., 2015) and there are increasing numbers of these children living in the South Island. It is also known that prompt effective initiation of cardiopulmonary resuscitation can reduce this mortality (Cooper & Cade, 1997) (Herlitz, Bang, Alsen, & Aune, 2002).

There are a variety of specific interventions that have been implemented with the aim of reducing paediatric mortality and morbidity. These include:

1. Public Health Initiatives
    a. Immunisation, reduction in cigarette smoking, 'safe sleep' or 'back to sleep' campaigns (Gunn, Gunn, & Mitchell, 2000).
2. Involvement of Specialist Teams within the Hospital
    a. Medical Emergency Teams (MET), Rapid Response or 'Crash Teams' (Tibballs, Kinney, Duke, Oakley, & Hennessy, 2005).
3. Clear algorithms that easily translate into practice
    a. Paediatric Early Warning Score (PEWS) (Fuijkschot, Vernhout, Lemson, Draaisma, & Loeffen, 2015)
4. Continued Education of Individuals and Teams such as Clinical Simulation

It is clear that the most significant improvements in paediatric healthcare will be achieved with a coordinated approach involving public health, community and hospital inpatient care using the concept of 'marginal gains' in each area. The purpose of this thesis was to specifically evaluate some of the published and observed evidence for improving interprofessional simulation based paediatric training with reference to educational theories.

1.3 Patient Safety

Patient Safety is an area of healthcare that has received increasing attention since the publication of 'To Err is Human' by the Institute of Medicine in 1999 (Improvement, 1999). This report highlighted the fact that up to 98 000 people were dying every year because of adverse events in the USA and it was released to make it clear that significant system wide changes needed to be implemented in order to prevent further avoidable patient harm. These figures have been replicated in several countries in both adult and paediatric patients (Soop, Fryksmark, Koster, & Haglund, 2009; Vincent, Neale, & Woloshynowych, 2001) (Hogan et al., 2012) (Matlow et al., 2012) (van der Starre, van Dijk, & Tibboel, 2012) and a systematic review suggests that 1 in 10 patients will experience a significant episode of harm (de Vries, Ramrattan, Smorenburg, Gouma, & Boermeester, 2008). This has led to international, national and local patient safety initiatives in an attempt to minimize preventable patient harm. In New Zealand the estimate of harm is that almost 13% of hospital admissions are associated with harm or an adverse event with up to 15% of these associated with permanent disability or death (Davis et al., 2002) and a significant number of these were preventable (Davis et al., 2003).

The Health and Disability Commission (HDC) in New Zealand was one of the first national steps, independent of the Government, which aimed to improve patient care. It was established following the enactment of the Health and Disability Act in 1994 as a result of the Cartwright Inquiry (Cartwright, 1988). The roles of the commission include investigating complaints against healthcare practitioners as well as providing the code of patient rights and education. The Health Quality and Safety Commission (HQSC) was established in New Zealand in 2010 and provides a national lead in the improvement of patient care. One of its roles is overseeing the mortality review committees, which are elected committees that review deaths with the specific aim of highlighting associations that may improve future care. These include:

- Perioperative Mortality Review Committee
- Child and Youth Mortality Review Committee
- Family Violence and Death Review Committee

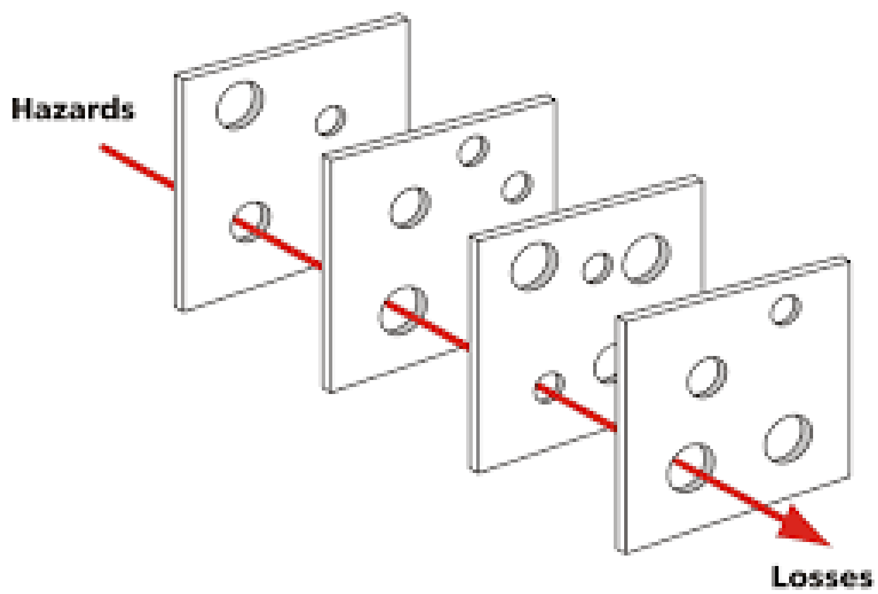
- Suicide Mortality Review Committee
- Perinatal and Maternal Mortality Review Committee

The HQSC also has a role in promoting patient safety and the sharing of positive patient safety initiatives that include:

- Medication Safety
- Infection prevention and control
- Reporting of adverse events (episodes of patient harm)

An increasing knowledge within the healthcare community of the importance of adverse events in patient harm stimulated the development of theoretical models of error that included the Swiss Cheese model (Fig 1) (J. Reason, 2000).

Figure 1: Cheese Model of Adverse Events (Patient Harm)



Each layer of cheese represents a barrier that aims to prevent identified hazards reaching the patient. The holes represent those 'latent' errors, that may represent a design fault in processess or procedures, as well as 'active' errors, such as those made by an individual.

The Swiss Cheese Model had been proposed as a model of organizational error by James Reason in 1990(J. Reason, 1990) and was adopted as a useful model for healthcare in 2000(J. Reason, 2000). One of the strengths of this model was that it created a visual picture of the multiple factors and weaknesses within any system that contributed to patient harm. This was a significant development in thinking to the previous understanding that had often held that an individual was wholly responsible. This was usually the professional who had had direct contact with the patient and effectively represented the last slice of the cheese. The model proposes that the holes in the cheese represent both latent errors, which can be considered as hazards within a system, and active errors that can be directly observed as mistakes.

As with many models, the Swiss Cheese Model is receiving increasing criticism, especially as a model for guiding safety innovations (Perneger, 2005) (Li & Thimbleby, 2014) (Underwood & Waterson, 2014). One of the criticisms has been that it can be interpreted as a static model when healthcare is a complex, constantly changing, dynamic environment. As a consequence a number of other theoretical models are increasing in popularity. These include the related concepts of 'High Reliability Organisations' and 'Resilient Organisations' as defined below:

High Reliability Organisation

'An organization that has succeeded in avoiding catastrophes in an environment where normal accidents can be expected due to risk factors and complexity'

Resilient Organisation

'Ability of an organization to anticipate, prepare for, respond and adapt to incremental change and sudden disruptions in order to survive and prosper'

These definitions are helpful in providing ultimate aims for complex organisations such as those involved in healthcare, but the specific factors within an organization that contribute to reliability and resilience are less obvious and may not help those working at the sharp end of healthcare in the same way as the swiss cheese model has. The term ‘mindful organisation’ has been used to describe what is observed within a resilient or high reliability organization (Weick, 2003). This term suggests a heightened awareness by individuals and groups of individuals of conditions that increase patient risk. A fundamental requirement for this is a universal understanding amongst all of those working in health care of what their own and others contribution to error is, and what conditions make these patterns more likely.

An improvement in the understanding of what contributes to patient harm has continued to evolve, and a significant amount of learning has occurred with the recognition that similar patterns of harm occur in other industries as well as healthcare. Humans are the common theme in these patterns that led to the concept of human factors that will be elaborated on in the next section. In addition adverse events (patient harm) have been shown to occur more frequently when there is poor teamwork behaviour (e.g Bristol Enquiry (I. Kennedy, 2001)) (Manser, 2009) providing educational initiatives that aim to improve teamwork behaviour has been proposed as one of the solutions (Fernandez et al., 2008; Morey et al., 2002) (E. Salas, DiazGranados, et al., 2008) (Hunziker et al., 2011) (McCulloch, Rathbone, & Catchpole, 2011) (Siassakos et al., 2011). The importance of social relationships, which includes teamwork, within an organization is also increasingly recognized as a feature of a high reliability and ‘mindful’ organization (Baker, Day, & Salas, 2006).

1.4 Human Factors and Human Error

The terms human factors and human error are now widely used within healthcare as well as other complex organisations. There are problems with both terms in that the first is frequently referred to but is ill understood by many. The second term is also valid but can stimulate significant emotional responses by both those that have made an error and those who think they never will! Two definitions of Human Factors are below:

‘Human factors examines the relationship between human beings and the systems with which they interact by focusing on improving efficiency, creativity, productivity and job

satisfaction, with the goal of minimising errors. A failure to apply human factors principles is a key aspect of most adverse events in health care. Therefore, all health-care workers need to have a basic understanding of human factors principles'.

(WHO, Topic 2, What is human factors and why is it important to patient safety? 2013)

'Enhancing clinical performance through an understanding of the effects of teamwork, tasks, equipment, workspace, culture and organisation on human behaviour and abilities and application of that knowledge in clinical settings'.

(Catchpole 2010)

Martin Bromley is a pilot with human factors expertise who lost his wife as a result of a healthcare system unfamiliar with the relevance of human factors and he has proposed a definition that has validity because of his expertise and usability because of its simplicity:

'Making it easy to do the right thing'.

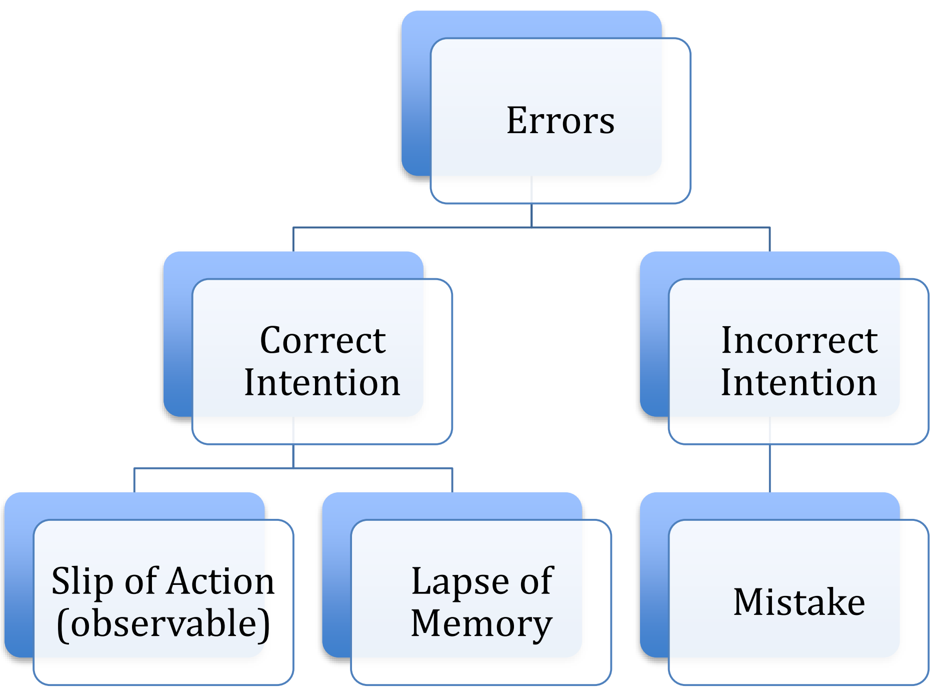
(Bromley 2010)

All of these definitions make it clear that humans have patterns of behavior that are predictable and that there are internal conditions and external contexts that influence these behaviours (J. Reason, 1995). Human factors should be considered in both the physical design of patient environments, the healthcare processes that surround them and the social context in which they happen. The aim of employing human factors in these design processes is that it will be 'easy' for both patients and staff to do the right thing. A natural consequence of paying attention to this should be increased efficiency and less risk of patient harm despite known hazards.

The term human error is related to human factors and was originally proposed to move away from the role specific terms of 'driver error', 'pilot error' and 'doctor error'.

Human error has now been widely adopted as being a contributory factor to a wide range of accidents within healthcare, aviation and other areas although this does not yet appear to be universally accepted within healthcare (Spencer, 2000) (Ottewill, 2003; Sexton, Thomas, & Helmreich, 2000; Sockeel et al., 2009). The intent of using a term such as human error had been to improve the understanding of the contribution of human behavior to adverse events but the term itself obviously has negative connotations. It is also true that humans have the ability to rescue situations and sometimes produce outcomes that were thought impossible. This has stimulated a renewed interest in the characteristics of healthcare when things go well (James Reason, 2008). James Reason described specific patterns of error that the Institute of Healthcare Improvement (IHI has organised into the chart below (www.ihi.org) (J. Reason, 2000) (Figure 2)

Figure 2 A Model of Human Error



The errors can be classified as those where the intention was entirely correct, but there were mistakes in delivery, and those where the intention was incorrect.

This chart can be conceptualized with reference to the 'Thinking Fast Thinking Slow' or systems thinking described by Daniel Kahneman (Kahneman, 2011) for which he won the Nobel Prize in economic sciences. Slips and lapses are common mistakes that occur when humans are thinking fast, that is they are functioning on 'automatic pilot' because it is something they are familiar with and they are taking mental short cuts to save energy, which all humans do. An example of a slip is accidentally putting salt on your breakfast cereal rather than sugar. That was not your intention but the salt was in a similar container. An example of a lapse is forgetting to put your wallet in your briefcase, or forgetting to stop at the supermarket on your way home. These are pervasive human errors that we cannot eradicate. Mistakes are more complex and are influenced by a multitude of factors including personal cognitive biases. An example of a mistake would be continuing down a patient management pathway despite evidence to the contrary. This error can be minimized by taking the opportunity to think slow but this requires time and mental capacity which is not always available. The term 'human performance characteristics' has been used instead of human error and this has less negative connotations but is not widely used in the literature.

2 Teamwork, Teaming and CRM

In this chapter the concepts of teamwork and crisis resource management and their relationship will be reviewed. The term 'teaming' will also be introduced and the context of these terms in relationship to the interprofessional teamwork required in acute paediatric care will be discussed.

2.1 Teamwork

Teamwork is a frequently used term in common language that is a broadly understood concept of working together for a shared outcome. This concept has been studied and refined in many 'team' sports for decades, if not longer. It is also being increasingly used in healthcare as it is now recognized as a core factor in patient safety (Leonard, Graham, & Bonacum, 2004) (Baker, Salas, King, Battles, & Barach, 2005) (Baker et al., 2006; Emanuel et al., 2008) (Kilner & Sheppard, 2010) (Zeltser & Nash, 2010). An example of a definition of teamwork used in sport is below:

'Work done by several associates with each doing a part but all subordinating personal prominence to the efficiency of the whole'

This definition is particularly explicit about each individual team member subordinating personal prominence. This has parallels with the situation in healthcare and it can be argued that the only member of a team that should have personal prominence in healthcare is the patient. One definition of teamwork that has been used in health care is:

'a dynamic process involving two or more healthcare professionals with complementary background and skills, sharing common health goals and exercising concerted physical and mental effort in assessing, planning, or evaluating patient care' (Xyrichis & Ream, 2008)

This definition applies to the 'teamwork' necessary for integrated and aligned collaborative care as well as the effective efficient teamwork necessary in an acute crisis. It emphasizes that the situation in healthcare is dynamic or constantly changing and that healthcare professionals with different backgrounds, skills or perspectives (professions) are necessary. Atul Gawande (a surgeon who has had a significant role in improving patient safety) has suggested that the teamwork skills now needed in healthcare are similar to those of the pit crew of a racing team. In support of this, the paediatric cardiac team of Great Ormond Street Children's Hospital in London worked with Ferrari and Mclaren to adopt some of these principles in the handover between surgical and medical teams after surgery (Catchpole et al., 2007). They significantly reduced error. It is likely that the teamwork necessary with an acutely deteriorating child or one that requires resuscitation can benefit from some of these principles although my own view, based on experience, is that these situations are complex and constantly changing and may require a combination of both standardization and flexibility.

Teamwork is a term that implies the work of a team and teams may be relatively stable, such as in sport or an operating theatre, or they may be more changeable (unstable regarding membership) with very little previous shared experiences, eg departments working together in rare events such as the acutely unwell child in the emergency department. It has previously been mentioned that doctors in training change roles regularly but it should also be remembered that senior medical, nursing and allied health staff are often more permanent and can provide a more stable framework within the team. The establishment of positive relationships within these groups can facilitate the development of a team culture.

The individual healthcare professionals contributing to a team and the team as a whole should be assessed and receive feedback regarding their teamworking skills and this can be one of the roles of clinical simulation. So what are the features of a team that are necessary for teamwork to occur and how can these be assessed? This is not always well understood, which is in contrast to the specific factors that will be outlined in the related term Crisis Resource Management. In considering the responsibility of each healthcare practitioner in contributing to teamwork an alternative term is 'teaming' (Edmondson, 2014) which is a verb and has been defined by occupational psychologists as '*teamwork on the fly'* and is explained in more detail in the next section.

2.2 Teaming

Although the terms 'team' and 'teamwork', and 'teamworking' skills are familiar to many, the term 'teaming' has been more recently proposed (Edmondson, 2014). Teaming is a verb and refers to the affective (feeling) and cognitive (thinking) skills in the development of the individual mindset and practices of teamwork. The use of the term affective provides further overlap with the concept of crisis resource management where both social and cognitive skills are necessary. The individual skills of teaming are those that contribute to teamwork and individuals should have both the skills and flexibility to implement these when required. It may be that framing teamwork in this way can be used to encourage individual responsibility in learning the skills to team.

Key features of ability to team are acknowledgement of interdependence and an emphasis on coordination and cooperation, and these are often skills that need to be learned. The leadership necessary to cultivate individual teaming has been described as one that cultivates an environment that fosters learning with learning behaviours that include (Edmondson, 2014):

- Asking questions
- Sharing information
- Seeking help
- Talking about mistakes
- Seeking feedback

A healthcare individual may be a member of a several different teams at one time or at different times even within the same day. An example would be a medical registrar working in the Intensive Care environment who is also part of the emergency resuscitation team that contains team members from paediatrics. The situation becomes even more complex when consideration is given to how individuals identify with their own profession (professional team) compared to their multiprofessional clinical department (departmental team) (J. Weller, Boyd, & Cumin, 2014).

2.3 Practicing Teaming and Demonstrating Teamwork

A recent article (Eduardo Salas, Sims, & Burk, 2005) on teamwork aimed to provide evidence for five core features of effective teamwork as well as supporting coordinating mechanisms. The five core features are:

- Team Leadership
- Mutual performance monitoring
- Back up behaviour
- Adaptability
- Team orientation

Theories and models of effective leadership are a fertile ground of study, and its importance in maximizing the potential of individuals within a team as well as the team itself cannot be ignored. In an acute situation the main areas of importance are that it is clear who is leading or coordinating, that the leader has the 'big' picture, is not distracted by performing tasks and that they are able to coordinate the collective intelligence, empowering others to contribute information. The term mutual performance monitoring has been used in the airline industry; this is used to describe a situation of clear understanding of the team environment that enables accurate monitoring of each other based on acceptance of the inevitability of human error. This then encourages explicit communication and cross-checking. Back up behavior was used in the above article to describe the skills of anticipating the needs of colleagues with an ability to be flexible in the redistribution of tasks. Adaptability refers to an ability to change strategies or direction or role when required and team orientation refers back to the original definition of teamwork from sport at the beginning of this chapter – the ability to place the team goal above individual consideration. Each of these five core features is associated with specific behaviours that can be observed within the workplace and simulation.

The coordinating mechanisms between these five core features include mutual trust, which needs little explanation, and the sharing of mental models which refers to a clear understanding by all team members and the group as a whole, of what the issues are, how they can be solved and what group interaction is necessary. The final coordinating mechanism refers to clear communication processes including closed loop communication (see below).

Although not specifically referred to in Salas' paper the wider sociocultural environment must also be one that encourages trust, and facilitates these behaviours of mutual cooperation and coordination previously described as necessary for teaming behaviours.

2.4 Crisis Resource Management

Crisis Resource Management (CRM) is a term that was proposed for healthcare by David Gaba, an anaesthetist (Howard, Gaba, Fish, Yang, & Sarnquist, 1992) and one of its advantages is that it is composed of clearly defined features in contrast to teamwork. CRM was developed from the concept of Crew Resource Management used in the airline industry since the 1970s, itself having developed from Cockpit Resource Management. The overarching concept of CRM is to maximize efficiency and effectiveness of individuals and groups of individuals in an acute healthcare emergency. This reflects similar concepts to the coordinated incident management system (CIMS) of the emergency services and civil defense that is on a larger scale and aims to provide a coordinated approach of all involved services during a large scale emergency. Both CIMS and CRM utilize a language that is clearly defined to maximize effective communication and minimize misunderstandings.

CRM within healthcare has continued to be refined from the original 7 components and these are listed below with the newer components shown in italics:

1. Know your environment
2. Anticipate and Plan
3. Ensure Leadership and Role clarity
4. Communicate Effectively
5. Call for help early
6. Allocate attention wisely and use all available information
7. Distribute the workload utilize all available resources
8. *Prevent and manage fixation errors*
9. *Cross (double) check*
10. *Use cognitive aids*
11. *Re-evaluate repeatedly*
12. *Use good teamwork principles*
13. *Set priorities dynamically*

I have organised these under specific categories to elaborate on the importance of each of these components when working together with colleagues in a paediatric crisis situation. These situations include an acutely deteriorating paediatric patient or one that has suffered a clinical arrest:

2.4.1 Individual and group preparation

1. Know your environment
2. Anticipate and Plan

Preparation is a key component to maintain a high standard of work and the types of preparation are many and varied. This can extend from the orientation of new staff to the physical environment and standard processes, to the use of clinical simulation to practice specific aspects that relate to patient care. One of the complications of the organization of healthcare is that doctors in training will rotate through departments at least every 6 months. It has been argued that just as they become fully orientated to the physical environment and departmental processes they move.

2.4.2 Team Structure and Roles

1. Ensure Leadership and Role clarity
2. Set Priorities dynamically
3. Use good teamwork principles
4. Call for help early
5. Allocate attention wisely and use all available information
6. Distribute the workload utilize all available resources

Teamwork has already been referred to and will be discussed in more detail below. In an acute situation the individual leading (coordinating or managing) should be fully aware of the 'big picture' or developing situation. It is clear from studying behavior in these situations that distraction of the leader in the performing of a task or by others is detrimental to the coordinated actions of the group. This is not universally understood and, in my experience, there is over reliance on a medical practitioner to be coordinating. Calling for help requires a culture where all are comfortable to ask and respond as well as clear processes that ensure efficient communication with the correct support through a paging or phone system.

2.4.3 Situational awareness

This refers to an awareness by the individuals and team of the developing situation and includes the following:

1. Prevent and manage fixation errors
2. Cross (double) check
3. Use cognitive aids
4. Re-evaluate repeatedly

The practitioner leading has responsibility in creating pauses for explicit re-evaluation of the current situation and the developing situation. This provides space for other team members to clarify and question and ensures that all members of the team are working together with the same objectives. A fixation error refers to the situation alluded to above where an individual is focusing on a specific task and loses track of other aspects of care as well as time. This is another 'human performance' characteristic and awareness of this helps it to be recognized.

2.4.4 Communication

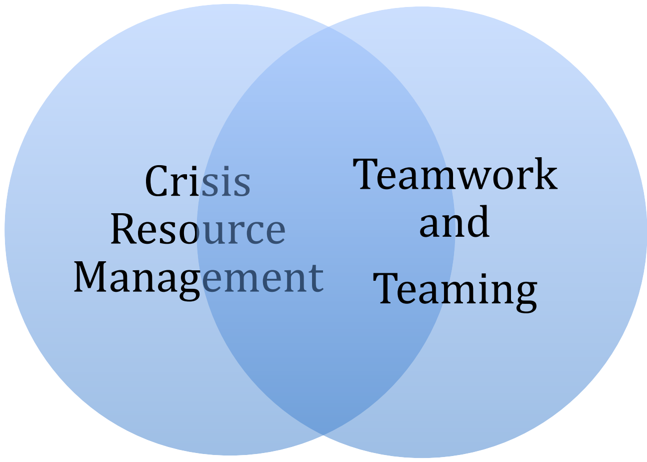
1. Communicate Effectively
2. Cross (double check)

Miscommunication has been highlighted as a major concern in a significant number of adverse events (episodes of patient harm) as well as being the most common reason for complaints to the health and disability commissioner. In an acute situation communication becomes even more critical. In these situations the administration of medication is common and the necessity for prompt administration may discourage staff from double-checking. Rrecognition that mistakes in calculation are more likely in these situations encourages staff to adhere to communicating and checking with a colleague. Other aspects of communication are further elaborated in the next section.

2.5 Teamwork and Crisis Resource Management

CRM refers to the 'non technical' skills that are required in order to maximize positive patient outcome from an acute clinical crisis. Individuals must also have expertise in the required technical skills but it is the way in which all of these individuals interact and coordinate their technical ability that determines outcome. The individual and specific role characteristics, their interaction and coordination, define the characteristics of the team and the teamwork observed. CRM can be considered as having a significant overlap with teamwork and the terms are often used interchangeably (figure 3).

Figure 3 The relationship of Crisis Resource Management and Teamwork



The terms CRM and Teamwork are not entirely synonymous but have a significant overlap.

The exact relationship between the terms CRM and Teamwork is open to debate. However, one of the points of difference is that CRM tends to be used in referring to an acute clinical crisis whereas teamwork is a term also used to describe collaborative work in sub acute or chronic situations. CRM includes the elements of preparation as stated below:

1. Know your environment
2. Anticipate and Plan

Communication is recognized as a key component of CRM and as an essential skill of teaming contributing to teamwork. As such it is discussed in more detail.

2.6 Communication

Communication is a key skill within CRM and teamwork as well as within other areas of healthcare requiring collaboration and negotiation. The use of standard terminology and processes may improve cross-disciplinary (or interprofessional) communication as it has with CIMS. This can be studied during simulation of acute paediatric scenarios as well as during workplace interactions. There are some specific tools and processes that have been developed to facilitate the exchange of patient information between individual professionals and teams and to encourage accurate verbal communication within an acute scenario which include:

- Use of the ISBAR mnemonic
    - The mnemonic **ISBAR** stands for **I**dentification (health professional and patient), current clinical **S**ituation, **B**ackground clinical details, the health care professionals current **A**ssessment and **R**ecommendations.
- Closed loop communication
    - Closed loop communication has the following features: a clearly directed message, receipt of the message confirmed by the recipient, clarification by sender that correct message interpreted. The recipient will then also clarify when a requested task has been completed if necessary.
- Call out
    - Call out refers to a member of the acute resuscitation team clearly verbalizing a change In-Situation that they have noticed. This may have the effect of refocusing other members of the team on an important area.
- Graded assertiveness
    - This refers to an increasing use of direct language to the leadership / coordinating team about an important aspect of the patients care that does not appear to have been recognized. This remains an area of research as it can exacerbate unnecessary conflict.

These communication tools are predominantly around the process of verbal communication that also includes the tone of delivery and the specific language or content of the verbal communication. As well as the verbal communication the importance of non verbal communication such as body language must not be undervalued.

3 Relevant Educational Theory

Clinical simulation is an educational method and as with any educational method it needs to be grounded in educational theory. This will ensure that it is used in the most effective way and that it integrates with other educational methods. This chapter aims to describe some relevant educational theories. Educational theory is a vast topic with a plethora of models and opinions but this short review is focused on educational theory relevant to clinical simulation.

Educational theory has developed as a specific field but is grounded in both the philosophy and the psychology of learning. In any study of clinical simulation, a basic understanding of the terminology of educational theory is important to provide a theoretical and evidence based framework for the application of clinical simulation to workplace learning of both the individual as well as interprofessional and departmental teams. Learning is often described as a natural consequence of human social behaviour and can be considered as having generic features, regardless of context, as well as specific characteristics defined by context. It is important to acknowledge that aspects of learning that are widely accepted within areas outside of healthcare remain valid within the context of healthcare and the context of healthcare also provides very specific situations that need to be considered when designing learning interventions.

Theory is the term used to explain what can be observed and to predict processes and outcomes that have not yet been observed. The use of the term model is slightly different in that it is a conceptual construct based on theory but explicitly open to refinement or modification. Some of the main theories and conceptual models commonly referred to when considering the area of learning in healthcare and specifically the area of clinical simulation are defined (and critiqued where relevant) below:

3.1 Human (Adult) Learning Theory

Malcolm Knowles originally used the term adult learning and this is now a term that is widely used in tertiary undergraduate education as well as postgraduate learning situations. Pedagogy remains a term used to describe learning within schools as it literally means 'child leading'. Andragogy is the term that means 'adult leading' and is synonymous with adult learning. Malcolm Knowles described 5 main features of adult learners that were originally thought to distinguish them from child learners (Knowles & III, 2012). These are listed below:

1. Self concept: Transition from dependent to self-directed
2. Previous Experience: Development of an increasing resource of learning
3. Readiness to learn:
4. Orientation to learning: A development towards problem-centred rather than task-centred learning
5. Motivation to learn: The development of internal motivation

The following principles were also put forward as important concepts when designing learning for adults:

1. Adults need to be involved in the planning and evaluation of their learning
2. Experience provides the foundation for their learning activities
3. The learning should be of relevance to them in either their personal or professional life
4. Learning should be problem-centred rather than content-orientated

Some of the differences between pedagogy and andragogy may have been artificially emphasized, possibly because of the didactic style of childhood education of the time. In reality there is no such rigid divide. The areas of pedagogy and andragogy have significant overlap and many now prefer reference to human learning rather then the child or adult (Jarvis, 2005). However the terminology and principles of andragogy as described remain useful when designing learning opportunities for health professionals including those provided by clinical simulation.

3.2 Behaviorist Theory

Most health care workers are familiar with the description of Pavlov's dogs, and the behaviorist theory of learning, which developed from this, was one of the first theories of education; a physiological response which is necessary will occur in association with the stimulus that requires that response e.g salivation with the presence of food or sweating with heat, and this is termed an unconditioned response. In the late 19th century Pavlov noted that his dogs salivated as he or his technicians arrived to give them food and he considered this a response that had been conditioned to the person who would supply the food, otherwise known as classical conditioning (Pavlov, 1928, 1951). Conditioned responses are those that are stimulated under specific conditions or contexts following a period of associative learning. An example of this learning within the healthcare environment would be the sympathetic neural response of clinicians to an emergency bell or pager.

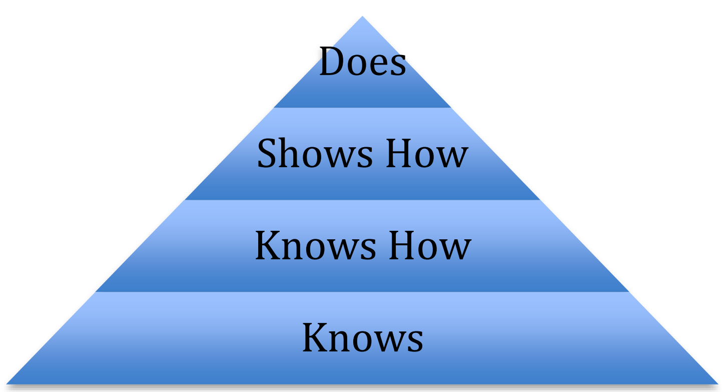
While classical conditioning refers to the conditioning to a stimulus presented in advance of an unconditioned response, another type of conditioning is operant conditioning. This was originally described by Edward L Thorndike in his Law of Effect in 1905 (Thorndike, 1905) and elaborated on by Skinner who coined the term 'operant conditioning' (Morse & Skinner, 1958; Skinner, 1938). Operant conditioning describes a process of shaping a particular behavior using positive or negative stimuli after the behavior to reinforce or extinguish that behavior. This type of conditioning has been commonly used in the modification of animal behaviours and with children. It is my observation that this theory has not been actively promoted among many educationalists involved with 'adult learning', possibly because it is thought to be a lower level of learning. However I believe it to be a crucial theory of learning in all mammals including human beings. A particular reason why some may consider this a lower level of learning and others a crucial area is that it can be responsible for learning that has occurred without awareness. This conditioning may be responsible for the observation that healthcare professionals behave differently in certain contexts and respond to specific unconscious stimuli, such as a particular smell or patient appearance, with an increased level of care because of the association of that experience previously with an unwell patient. This type of learning is often thought to be instinctive and contributes to the clinical acumen that accompanies experience.

Changes in behavior are consolidated and refined by repetition, with elements of classical and operant conditioning, and clinical simulation provides opportunities for this. It has always been acknowledged that repetition is an important way to create and consolidate learning and this is absolutely accepted within sport and music but not always acknowledged within healthcare. The recent use of terms such as 'rapid sequence deliberate practice' (Hunt et al., 2014) in the development of the technical skills of resuscitation has highlighted this important aspect of learning in healthcare.

3.3 Millers Triangle / Novice / Expert

Competence is a commonly used word to define a specific level of learning although its exact definition in specific areas may vary. George Miller was a psychologist who developed his pyramid of competence in 1990 as a way to create a hierarchy for assessment (Miller, 1990). Within this pyramid the lower two levels can be considered as referring to aspects of cognition or knowledge while the upper two levels refer to the associated behavior (Figure 4).

Figure 4 Millers Triangle



Where 'Does' refers to performance and 'Shows How refers to competence

The hierarchal relationship from knowledge to workplace performance has applicability to areas of clinical simulation. It is clear that when learning technical skills the learners can often accurately describe the procedure in detail but have not yet developed the psychomotor skills necessary to show how the procedure is carried out. The opportunity to practice these psychomotor skills either within the workplace or in a clinical simulation environment is consequently an important part of reaching a level of competence.

This model has been adapted by others in a number of ways, including the addition of a further level that refers to mastery (Dent & Harden, 2005) and the development of a model (Cambridge Model) which acknowledges the influence of factors within an individual as well as system factors or context (J-J Rethans & Southgate, 2002). The former adaptation aligns well with the novice / expert theory of Dreyfus and Dreyfus referred to in Patricia Benner's work (P. Benner, Tanner, & Chesla, 1992) (Patricia Benner, 2004) and the latter Cambridge model with the area of human factors within patient safety.

The Dreyfus model refers to the development of professional expertise through stages of being a novice, becoming increasingly competent (through advanced beginner stage) and then proficient and expert. This model is referred to within health care, although it is often simplified, and those with experience that should be regarded as proficient may be mislabeled as expert. The term expert refers to those in whom the performance is automatic and unconscious. Another way that this has been framed is that the expert concentrates on the outcome or results with no cognitive energy being focused on the process. As with other models this has been critiqued and the view of some medical educators is that experts or those with mastery require both 'instinctive' and 'reflective' skills. The original model had a background of learning what are referred to in simulation as technical skills and its precise applicability to non-technical skills, which include both social and cognitive skills, is not clear.

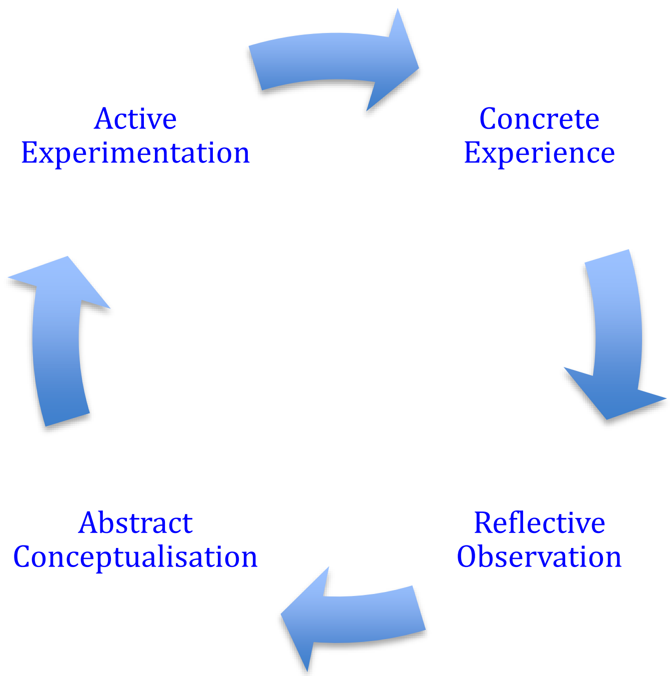
One of the goals of clinical simulation is to minimise cognitive energy expenditure during commonly experienced clinical situations, ie mastery or expertise in core areas with cognitive energy freed for the reflective analysis necessary in concentrating on outcome. A further goal is to begin to enable and embed those skills that are used more rarely because of the infrequent nature of a clinical situation.

3.4 Cognitive and Constructivist Theories of Learning

There are a number of theories of learning that incorporate the term 'cognitive' and consider how individuals understand knowledge, emphasizing terms such as thinking and reflection. Cognitive theories can be considered as having a basis in Gestalt psychology (the human mind as a whole) as well as the work of Piaget who related biological development to cognitive development (Jarvis, 2003). They were put forward by those educationalists that wanted learning to be defined by more than just observable changes in behavior. Cognitive theories have their emphasis on the process of learning and retention of learning and have continued to be critiqued and revised. The implication of some of these theories is that observation or knowledge can be deconstructed and reconstructed in specific ways that make sense to each of us. Indeed the term constructivism has been applied to emphasise the individualistic nature of learning, in that new learning is formulated within the past experience of the learner.

There is little doubt that within healthcare cognition is an important component of learning. Healthcare professionals benefit from being able to have a deep understanding of the complex relationships between areas such as physiology, pathology and pharmacology in each individual patient, so that their problem solving or interpretation of clinical symptoms and signs is not concrete but more abstract, and reflection is a crucial tool. The importance of experiences in contributing to learning, as well as reflection in and on that experience, must not be underestimated. A model that is almost synonymous with the terms experience and reflection is that of Kolb's Cycle (D A Kolb, 1975) (Jarvis, 2003) (Fig 5).

Figure 5 Kolb's Cycle of Learning



Concrete Experience: Doing / having an experience

Reflective Observation: Reviewing / reflecting on the experience

Abstract Conceptualisation: Concluding / learning from the experience

Active Experimentation: Planning / trying out what you have learned

Kolb's cycle of learning is referenced widely in healthcare and other areas. David Kolb is an educational psychologist whose main interest is in experiential learning. Experiential learning incorporates aspects of the subconscious and conscious reflective learning described above. The cycle can be considered as representing the circular, repetitive route of learning in most of us but also emphasizes that each of us have different priorities within our learning, and different learning styles. Clinical simulation is a concrete experience for those participating, and there are often observers who can be prompted to actively reflect. Skilled debriefing then facilitates further reflection and conceptualization, and often a further simulation then allows the opportunity to practice new techniques.

As with most learning theories, there have been critics of Kolb's learning cycle. Some educators have used it as the basis for a more complex contextual based cycle (Jarvis, 2003) (Jarvis, 2005) but in this simple form it provides a useful framework to apply within clinical simulation educational interventions.

3.5 Interprofessional Education (IPE) or Learning (IPL)

The accepted definition of interprofessional is that developed by the World Health Organisation and CAIPE (Centre for the Advancement of Interprofessional Education) in 2002:

"Interprofessional Education occurs when two or more professions learn with, from and about each other to improve collaboration and the quality of care"

In this definition there is a clear expectation that the 'with', 'from' and 'about' are core components and contribute a different cognitive and social perspective to the area of interprofessional learning. The combination allows each profession to develop the full perspective of other professions with whom they work, with the aim of enhancing interprofessional respect and organizational culture. One of its purposes was to make clear that the co-location of students from different professions within a lecture theatre did not qualify as valid IPE, although this could be termed multiprofessional education (MPE). It continues to represent the gold standard but one should not completely dismiss learning in which two or more professions are encouraged to interact and begin a process of developing interprofessional respect as well as interpersonal respect. Some educators have suggested that there should be levels of interprofessional learning as there may be benefits from joint tutorials if there is opportunity for discussion. The definition also has relevance during both the undergraduate and postgraduate education.

The sociological argument for IPE is that increasing the opportunity for interprofessional education will improve interprofessional working within an organisation, and the evidence for this has been extensively covered in a 'Best Evidence in Medical Education' (BEME) systematic review that was published in 2007 (Hammick, Freeth, Koppel, Reeves, & Barr, 2007). The main outcomes that were assessed were grounded in the evaluation model of Kirkpatrick (discussed later) and are listed below

- The reactions of learners to an IPE innovation (level 1)
    - 12 out of 21 studies reported a positive reaction.
- Whether there was a change in attitudes, knowledge or skills (level 2)
    - 15 out of 17 reported a positive change
- Whether learners showed a change in behaviour (level 3)
    - 5 out of 6 showed a positive change
- Impact on service users or service organisations (level 4)
    - 6 out of 8 showed improvement in care

The establishment of positive relationships between any group of individuals has been shown to improve team cohesion or collaboration and this is obviously part of the benefit of IPE innovations. An additional theoretical benefit is increasing familiarity with the role of another professional, which should improve the clarity of each professional regarding their own role and that of their colleagues from other professions, and increase the efficiency of communication. A concern with IPE has been that to be most effective the individual must first be familiar with his or her own role before being asked to comprehend the role of another professional. In my view this argument is not totally valid on a sociological construct as, in the correct environmental and learning context, individuals can develop their own roles side by side. There is evidence that even undergraduates arrive with a perception of the role of other professionals based on portrayed stereotypes, which can be a negative influence on the establishment of effective IPE. In addition, the roles within nursing and medicine are becoming less distinct which has both positive aspects as well as challenges.

The relevance to IPE in this research is within the area of acute collaborative practice or crisis resource management and the use of interprofessional simulation education as a training initiative. The following areas are those discussed in the Best Evidence Medical Education (BEME) review (Hammick et al., 2007) that have most relevance and they are elaborated on below:

- Role modeling from the educational faculty
- Gender
- Adherence to principles of 'Adult Learning Theory'
- Interprofessional teamwork
- Informal Learning

3.6 Role Modeling IPE

The phrase 'from and about each other' is part of the gold standard definition of IPE. As a result the educational faculty need to be multiprofessional and to demonstrate the qualities of a cohesive collaborative group that demonstrate inter professional respect as well as a depth of knowledge about the knowledge, skills and roles of other professions. In some inter professional education initiatives it has been mentioned that a 'valuable opportunity' was missed to model this behaviour. This in itself may happen when educators are no longer practising clinically or have little contact with the current workplace. In addition, educators from different professions may be unfamiliar with educators of other professions and may need orientating to the role of an interprofessional faculty.

3.7 Gender

Female participants in IPE have been shown to have a more positive attitude to it than male participants and gender has also been shown to have an effect on the group dynamics (Hammick et al., 2007) (Curran, Sharpe, & Forristall, 2007). In the past physicians were predominantly male but this has is changed and within paediatrics there is a high proportion of female physicians. This may or may not influence teamwork behaviours.

3.8 Adherence to principles of 'Human Learning Theory'

Adult Learning Theory has been described earlier and includes the concept of internal motivation. This has relevance to whether participants involved in IPE have any choice on whether they take part, and what their participation involves. In cases where participants felt that the IPE innovation aimed to address issues and obstacles that they had themselves highlighted, this was highly motivating and the important step was not to disengage them by the way in which the IPE was delivered. When considering an IPE episode of simulation, well-run debriefing often leads to staff feeling listened to and motivated to change. A barrier to change in these situations may be the negotiation with senior clinical staff and managers

3.9 Interprofessional teamwork

The specific application of IPE to team training or the improvement in teamworking is increasing and often has a specific focus on communication and providing opportunities to practice communication techniques that are likely to reduce patient harm during the delivery of emergency care. In some IPE teamworking innovations the IPE has been a particularly well received part.

3.10 Informal Learning

It has already been mentioned that the co-location of professions within a social situation or learning environment does not fulfil the criteria of interprofessional learning. However, there is an argument that relationships can begin to be established at these times and that informal learning does occur. This has been utilised for many years in large and small businesses although it has also been shown that only individuals with an interest in the roles of other professions maximise these opportunities.

In reality the provision of IPE is only one part of the solution to improve teamworking in patient care. The physical and psychosocial environment is also key and this aspect may be explored when the IPE simulation takes place 'In-Situ' with the personnel and workplace resources normally available.

4 Simulation within Healthcare

In this chapter the role of simulation as an educational tool within healthcare is explored within the context of the educational theories discussed in Chapter 3.

The word simulation has been in use since the mid 17th century and it has its origins in Latin from the verb 'simulare' which translates as 'to simulate'. This term simulate is widely used within industry and healthcare and literally means to 'imitate'. Although the exact definition depends on the context or specific application, a commonly used definition for the healthcare context is that from the Center for Medical Simulation (CMS) Boston:

'A situation or environment created to allow persons to experience a representation of a real event for the purpose of practice, learning, evaluation, testing or to gain understanding of systems or human actions

(Robert Simon)

Simulation based education within healthcare is developing into a very specific field with its own terminology. The definitions associated with this terminology have recently been refined to enable the development of a common language (Lopreiato, Gammon, Slot, Concepts, & Group., 2016). Even within healthcare, the term simulation refers to a wide variety of educational experiences. In the clinical contexts described as part of this thesis the term 'clinical simulation scenario' 'refers to the use of manikins or actors as part of the educational experience to allow real life clinical scenarios to be enacted. This enactment may be within an educational facility (simulation centre or simulation laboratory) or within the departmental workplace (In-Situ). These experiences may be technically simple and low cost or increasingly complex using cutting edge engineering and digital technology. Simple low cost examples include using a clinical case (paper or electronic format) in a way that allows individuals and teams to practice the application of knowledge in decision-making, or the use of a banana skin to practice suturing. These remain valid approaches in many situations despite the availability of more expensive possibilities. As the area of simulation within healthcare has expanded, companies that design and market tools for simulation have become established (http://www.laerdal.com/nz/ and http://www.gaumard.com). These now produce tools that simulate specific areas of the body (part task trainers) as well as increasingly complicated full body manikins (previously known as high fidelity) that can exhibit breathing, sounds including speech and a wide variety of movement. The area of 'virtual' computerized simulation is also expanding which contributes to an increasing financial cost in the establishment of a clinical simulation based program. An even more significant contributor to cost are the technical and educational skills of the educators that organize and run simulation as well as the fact that clinical simulation scenarios are small group learning methodologies.

Simulation education is developing a role in the undergraduate curriculum of the medical, nursing and allied health professions as well as in the continued education of the postgraduate workforce, where interprofessional and interdepartmental collaboration is required. The location of the simulation experiences may be within an educational facility such as a simulation centre, which is the commonest situation in undergraduate training, or within the workplace (In-Situ) (Figure 6). A postgraduate simulation program is likely to incorporate experiences in both of these environments.

Figure 6 In-Situ simulation on the neonatal unit

There continues to be discussion about the relative contribution of simulation centres and In-Situ based simulation, and there are strengths and weaknesses that need to be considered with both. There is considerable financial cost associated with the construction and internal design of a simulation centre but one of the advantages is that these are seen as educational facilities and candidates are formally released from workplace duties. An advantage of In-Situ simulation is that it can more accurately imitate real life interactions with the working environment and as such is able to highlight latent errors. The set up for In-Situ has to be carefully thought out to ensure that there is no risk to patient care. Clinical simulation as part of a simulation program is increasingly being used as a patient safety innovation to develop the collaborative skills of teamwork and Crisis Resource Management that is the topic of this thesis.

4.1 Theories of Education and Clinical Simulation

The design of an educational curriculum to maximize learning of both individuals and departments within the healthcare environment in the most efficient (time and financial cost) way with the most benefit to patients continues to be studied. The educational methodologies used should be grounded in educational theory, with the more expensive simulation techniques being reserved for specific situations, where the theoretical and practical evidence suggests that they are the most effective. It is likely that a blended educational approach is necessary that also utilizes e-learning strategies, and an understanding of educational theory facilitates optimal design of this approach. Clinical simulation provides an experience along a spectrum from discussion of a case through the use of a part task trainer that is increasingly lifelike within classrooms to learn cognitive and psychomotor skills, to a physical and sociocultural environment within the workplace with a 'manikin' or 'humans' playing the role of patient. This latter involves assimilation of the cognitive, emotional, psychomotor and social skills, and fidelity is the term now used to refer to the reality of this experience. Two separate but linked processes that encourage learning within clinical simulation involve:

- Stimulating and creating automatic learned responses within an individual (classical and operant conditioning) as well as 'testing' an environment

- Enacting a process or procedure to stimulate learning and encourage conscious reflection

4.2 Psychomotor or Technical Skills

Simulation is an effective educational tool for learning psychomotor or technical skills (Wang et al., 2008) (Calaman, McGregor, & Spector, 2010; Scalese, Obeso, & Issenberg, 2008) (Cant & Cooper, 2010) (Calaman et al., 2010) (Hunt et al., 2014):

- Reference to Millers Triangle (Section 3.3) provides a framework for this learning's.
    - Each skill needs to be built on a foundation of core knowledge that includes aspects such as when the skill is needed, what risks it poses to the patient and how the procedure is done. This can be developed using a combination of self-study and teacher-facilitated learning, utilizing the written, aural, and electronic resources.
- The simulation strategies can be considered as being reserved for the 'does' level of Millers Triangle.
    - New technical skills can be learnt away from patients using standardized anatomical part task trainers.
        - One strategy may be to ensure a certain level of competence (sign off) in core technical skills before performing on a patient
        - Training in technical skills that are rarely required can also happen away from a patient
        - Core technical skills can be periodically 'practiced' to ensure maintenance of skill competency.

It is important to understand with reference to Millers Triangle that we may have the knowledge necessary to perform a skill and we may be able to describe how that skill is done but we need to 'show how do it' to provide the evidence that we can do it. The behaviourist and constructive theories can also be used to explain the effectiveness of this approach. The learning of any psychomotor skill (in sport and music for example) requires repetitive practice, similar to that offered in clinical simulation, with feedback to refine the technique. This feedback may take a variety of forms, including self reflective feedback during the performing of the procedure as a consequence of its success or not (Schon's reflection ***in*** action (Schon, 1083)). Debriefing is the term used for feedback after completion of the procedure (Schon's reflection ***on*** action (Schon, 1083)), the aim of which is to stimulate reflection and active reconstruction of new ideas. This cycle of learning a technical skill by experience (experiential learning) also maps onto Kolb's cycle that reinforces the importance of repetition with feedback and reflection. A single simulation experience can be used to promote discussion and reflection but in a similar way to learning within the workplace it is clear that multiple similar experiences are necessary to consolidate or refresh learning.

4.3 Simulation Scenarios and Resuscitation Courses

The use of specific clinical simulation scenarios is the most personnel resource heavy aspect of simulation and needs to be focused towards aspects of healthcare where there is no proven alternative educational methodology and where evidence continues to accumulate as to its effectiveness. This evidence should ideally equate to a demonstrable change in individual and / or team behavior (Kirkpatrick level 3).

Clinical Simulation Scenarios can be designed to simulate almost every clinical situation that may occur within the workplace. This may range from a challenging conversation with a patient, family member or professional colleague to the management of a life threatening diagnosis, and can be divided into commonly encountered situations or the more complex rare situations. For example

- The simulation of common clinical scenarios can be used to move inexperienced staff towards competency in the integration of technical, non technical and social skills in a specific clinical situation

- The simulation of complex or rare clinical situations can be used to familiarize all staff, including experienced senior staff, with optimal management strategies.

Clinical simulation has been used as part of the training on resuscitation courses since the end of the 20th century. These courses contributed to development of the standardization of processes and training in resuscitation and have played a significant role in developing exposure to simulation. There are several resuscitation courses internationally that have been developed to improve paediatric resuscitation skills. These include:

- Neonatal Life Support (UK and NZ), NLS
- Neonatal Resuscitation Program (USA), NRP
- Paediatric Advanced Life Support (USA), PALS
- European Paediatric Life Support (Europe), EPLS
- Advanced Paediatric Life Support (UK and Australasia), APLS

These courses are either mandated or strongly encouraged by professional organisations within each country, and common recommendations are that the course should be repeated every 3 years. As resuscitation protocols have become increasingly evidence based and clear, the role of these courses has been debated (Ali et al., 1996) (Jabbour, Osmond, & Klassen, 1996) (Jewkes & Phillips, 2003; Waisman, Amir, & Mimouni, 1997). A single episode of resuscitation training every few years cannot be considered as a demonstration of competence and these skills must be regularly practiced. This understanding, together with increasing availability of data regarding outcome from in hospital arrests, has prompted an increase in In-Situ resuscitation practice, and the organisations that provide patient care have an ethical obligation to ensure that this is available.

4.4 Changing behavior and improving teamwork

The focus of interest in this research is particularly on aspects of the individual cognitive and social behaviours (or non technical skills) associated with teaming and Crisis Resource Management that combine to demonstrate teamwork in an interprofessional paediatric acute clinical situation. Evidence is beginning to accumulate that simulation-based learning (SBL) can improve aspects of communication, and develop teamwork (McCulloch et al., 2011; E. Salas, DiazGranados, et al., 2008) (Elliott et all 2011). This has been demonstrated to be associated with improvements in patient safety (Gordon, Darbyshire, & Baker, 2012).

In a clinical scenario both technical and non-technical skills will be observed, but it is widely accepted that a basic level of competence in the required technical skills should be assured before practitioners participate in complex scenarios. If a technical skill is requested and a practitioner is not competent, they must have the social and communication skills to make that clear. In some departmental cultures, the emphasis on individual capability may make this more difficult and the ability to do this can be considered a marker of a patient-centred team-based culture in an acute situation.

In areas where staff from multiple departments comes together, such as the emergency department, simulation has demonstrated the confusion that can result from differing opinions, unclear leadership and even the language of communication. A first step of an organized simulation program may be to develop and define core language, and standardize communication. A second step may be to have a detailed understanding of roles and the characteristics of effective coordination or leadership, and to develop clear processes and protocols. A final step is to practice or simulate. Evidence for these steps will be discussed in the results and conclusion.

4.5 Debriefing a Simulation

Feedback is well known within education to be an important contributor to learning, and it is also an integral part of simulation. There have been those who have considered the main point of simulation as being an opportunity to provide feedback, which obviously ignores the predominantly behaviorist and experiential component of the 'doing'.

The term feedback can imply a unidirectional approach from 'teacher' or 'expert' to 'learner' or 'novice' and is often interpreted as referring to verbal feedback either during or after an episode of learning. It is important to remember that other forms of feedback, such as the patient's response to treatment, the communication (verbal and non verbal) with colleagues, as well as reflection in action (Schon) are equally valid although that will not be elaborated on here. Verbal feedback should be framed as a conversation to build on the 'learners' current knowledge construct (constructivist theory). This requires both a strong motivation on the part of the learner to improve, and a willingness of the teacher to listen and understand from the learner's point of view and to minimize assumptions and poor judgment.

A definition of debriefing, from the Center for Simulation in Boston USA is below:

'A conversation between two or more people to review a real or simulated event in which participants analyze their actions and reflect on the role of thought processes, psychomotor skills and emotional states to improve or sustain performance in the future'

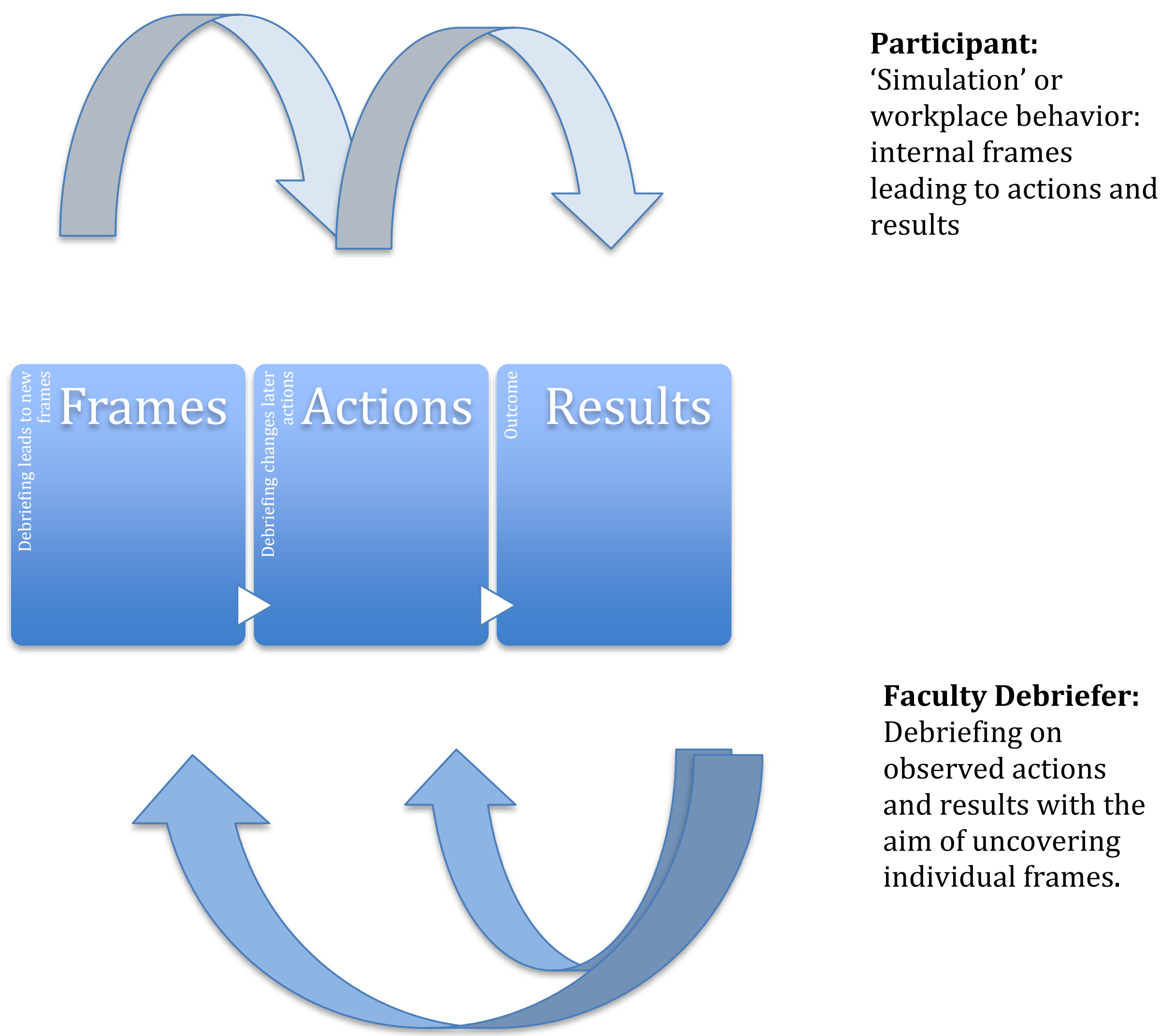
The term is often used synonymously with feedback but the use of the term emotional in the above definition also implies that it is more than constructivist feedback. It often includes explicit questioning about how candidates feel and have felt under similar challenging circumstances at work.

There are a variety of feedback tools, all of which may have a role in debriefing healthcare practitioners following either a simulated or a clinical event. A commonly used tool is 'plus delta', which had its origins in commercial aviation. The headings of plus and delta are used where the plus refers to strengths and the delta for areas that require change

The CMS teach a specific method that is termed ‘advocacy inquiry’ which was published in a paper entitled ‘debriefing with good judgment’ (Rudolph et al., 2006). Internal Frames lead to Actions, which leads to Results: Actions and Results are directly observable while frames are *inferable* and the Instructor inference may be incorrect. The advocacy Inquiry method aims to elucidate and build on the frames of the candidate. Two of the main features of this debriefing method are:

- The debriefer expresses their own opinion about actions or results which they have been able to directly observe
- The debriefer asks a question of the candidate in relation to this which aims to understand the ‘frame’ or ‘cognitive construct’. (Figure 7)

Figure 7 Advocacy Inquiry Model of Feedback



The effective implementation of this method requires that the faculty delivers the feedback in a way that demonstrates their belief in the 'basic assumption' written below;

'We believe that everyone participating at activities at CMS is intelligent, capable, cares about doing their best, and wants to improve'

This method has broad implications in many industries and professions, not just in healthcare, and the evidence is that it sometimes gets at the heart of misunderstandings and assumptions and can increase awareness of the importance of specific language and communication processes. It is a technique that is particularly useful when it is not completely clear why something has or has not occurred. It enables the instructor to clarify an expected action or result without negatively 'judging' individuals. The exposure of a particular frame (reason for behavior) creates an opportunity for specific individual feedback that is likely to be effective as it builds on the perspective of the individual.

There are other tools but the 'advocacy inquiry' method is most commonly referred to within the area of simulation. The initial questions often lead to discussion within the wider group and at the end of the session the areas of learning are reflected on and generalized to others' shared clinical experiences.

5 Evaluating Educational Outcome

The aim of this final background chapter is to introduce the Kirkpatrick model of evaluation, and to introduce some teamwork evaluation tools.

A model for evaluating the outcomes of training was proposed by Dr Don Kirkpatrick in the 1950s (Kirkpatrick & Kirkpatrick, 2005). This has since been developed further and provides a useful framework for evaluating educational innovations and research (Kirkpatrick & Kirkpatrick, 2007). The framework is below:

Level 1: Reaction

- This refers to the reactions of those that have participated in training, and often refers to their level of enjoyment of the session

Level 2: Learning

- Evidence that the participants have experienced a change in attitude (2a), knowledge or skills (2b) as a result of the education / training

Level 3: Behaviour

- Evidence that the behavior of those that have participated has changed as a result of their learning

Level 4: Results

- This refers to changes within an organization that have occurred because of the education / training that has occurred. In the context of this thesis this would refer to changes resulting within the workplace and ultimately improvements in patient outcome.

This model is an extremely good one to keep in mind when designing educational innovations and research into education, as it frames the learning around both the individual and the organization. Although it is often presented as a hierarchal model, the importance of level 1 reactions should not be underestimated, as positive reactions to learning episodes are strong motivators for individual engagement. This may subsequently lead to organizational change, but it can take many months or years to reach a ‘tipping point’.

This framework will be referred to in the interpretation of the literature review.

5.1 Teamwork Checklists and Tools

Both checklists and tools can be considered as psychometric instruments that have been designed to specifically measure aspects of psychology or behavior, although a simple checklist is often nothing more than a hint to guide observation. One of the reasons why they are used is to provide an objective comparison regarding the behavior of a single population over time following an intervention or to compare two separate populations.

In using psychometric instruments it is useful to be aware of the following:

- Design process

  This is often summarized as inductive (new observations) or deductive (based on expert knowledge and theoretical evidence). Items to be used in the tool also need to be considered for relative significance so that a scoring system can be designed.
- Validation process

  Those that have led the design of an instrument are not usually the same population that will have their behavior measured. As such the tool or instrument needs to be validated to see that it really does do what it is meant to do. Validity and reliability figures are generated and factors within the tool that are not as discriminating may be excluded from the final instrument.
- Context of both design and validation

  A tool’s validity is measured in a specific context and its validity in a different context cannot be assumed.

A brief summary of some of the most commonly used tools is provided in the section below;

5.1.1 TeamSTEPPS

STEPPS is an abbreviation for Strategies and Tools to enhance Performance and Patient Safety. Team STEPPS provides one of the most commonly used Teamwork Tools (King et al., 2008) and it was developed specifically to translate lessons learned in aviation to healthcare, further emphasizing the overlap in CRM and Teamwork. It was developed from the MedTeams program, a joint civilian and military program, and has been further developed by the Agency for Healthcare Research and Quality in the United States of America.

The aim of TeamSTEPPS is to provide an evidence-based framework to improve institutional collaboration. The five key principles of their core curriculum are:

- Team Structure
- Communication
- Leadership
- Situation Monitoring
- Mutual Support

The team observation tool is based on these five key principles and the TeamSTEPPS resources are freely available online :(http://www.ahrq.gov/professionals/education/curriculum-tools/teamstepps/index.html).

5.1.2 ANTS

The Industrial Psychology Research Centre of the University of Aberdeen developed the ANTS system. ANTS stands for Anaesthetic Non Technical Skills System (Fletcher et al., 2003) and is based on the following four categories, each of which is further subdivided into specific elements:

- Teamworking

    Coordinating activities with team members, exchanging information, using authority and assertiveness, assessing capabilities, supporting others.

- Task Management

  Planning and preparing, prioritizing, providing and maintaining standards, identifying and utilizing resources
- Situation Awareness

  Gathering information, recognizing and understanding, anticipating
- Decision Making

  Identifying options, balancing risks and selecting options, re-evaluating

Although this tool is used predominantly within anaesthetists, it has been used in other areas, and was designed by the Industrial Psychology Research Centre of the University of Aberdeen who are world leaders in the understanding of human factors and teamwork. They are also responsible for the NOTECHS instrument, used in the assessment of non technical skills of airline pilots, which has been adapted for use in the Operating Theatre (Mishra, Catchpole, & McCulloch, 2009).

5.1.3 Simulation Team Assessment Tool (STAT)

The aim of the STAT tool was to evaluate decision-making, technical skills and human factors during simulated paediatric resuscitation (Reid et al., 2012). The tool was developed using a deductive approach with reference to:

- Paediatric Advanced Life Support Course
- Tool for Resuscitation assessment using computerized Simulation (TRACS)
- Review of published checklists

The items were then reviewed by a series of clinical experts and the completed tool contained 94 elements.

5.1.4 Paediatric Resuscitation Leadership Tool

The aim of the 'Leadership' tool was to assess paediatric residents on their competence as a team leader during a simulated resuscitation (E. C. Grant et al., 2012). This was developed using a combination of an inductive and deductive approach; items to be considered for inclusion were chosen by reference to:

- Expert brainstorming
- Literature review

The completed tool contains 26 items.

5.1.5 TEAM Tool

The aim of the TEAM tool was to be a resuscitation teamwork assessment tool to be used with resuscitation and trauma teams in simulated and clinical settings (Cant et al., 2016). There were 5 stages in its initial development that used a combination of deductive and inductive approaches:

- Literature review for teamwork instruments
- Development of a draft instrument with an expert clinical team
- Review by independent experts
- Instrument testing on video recorded and simulated resuscitation events
- Rated for feasibility on simulation events

The tool has 11 items.

5.1.6 OSCAR Tool

The Observational Skill-based Clinical Assessment Tool for Resuscitation (OSCAR) was developed from the Observational Teamwork Assessment for Surgery (OTAS) and is designed to assess resuscitation teams in the following behaviours (Walker et al., 2011):

- Communication
- Cooperation
- Coordination
- Monitoring / situational awareness
- Leadership
- Decision Making

Each of these items is rated using a Likert scale of 0-6.

5.1.7 Comparison of TEAM and OSCAR

The TEAM and OSCAR tools have similar aims and contain similar skills sets. The tools have been directly compared and showed strong correlation and inter-rater reliability, confirming that they are both valid tools to assess non-technical skills in resuscitation (McKay, Walker, Brett, Vincent, & Sevdalis, 2012).

5.1.8 Behaviour Assessment Tool

This tool was developed using a modified Delphi method to develop a weighted scoring tool (E. C. Grant et al., 2012) and has been validated in the paediatric environment. The inter rater reliability of the modified tool was 0.8 and was shown to demonstrate statistically significantly different results between junior and senior trainees.

5.1.9 Teamwork in Intensive Care

This teamwork measurement tool is included because it is the result of work by clinicians that have been leading simulation within New Zealand for a number of years. This tool was designed to be used with trained assessors observing Intensive Care Teams during a critical event. The tool consists of 23 items. It is of specific interest that this tool has also been validated for use in the self-assessment of teamwork during simulated critical events (J. Weller et al., 2013). Factor analysis confirmed the validity of 19 items that aligned with the following aspects of teamwork:

- Leadership and team coordination
- Sharing situational information
- Mutual performance monitoring

The self-assessment scores were also statistically compared to scores by external assessors. There was a strong correlation between the scores for overall performance. The participants tended to rate their own team higher in leadership and team coordination and sharing situational information while the assessors rated teams higher in mutual performance monitoring.

5.2 Disadvantages of using a Teamwork Tool

The use of either a checklist or tool is designed to focus the attention of the person who is completing the checklist or tool onto specific areas. This has the advantage of yielding an objective score and allowing a numerical comparison between groups. There are some disadvantages with this approach:

- The checklist or tool effectively biases the observer to focus on specific information and this may mean that unanticipated information will not be documented.
- The validity and reliability of tools demonstrated during their construction may vary when applied in different psychosocial or environmental contexts.
- It is usual for inter rater reliability to be < 0.8 i.e not 1.0.
- The number of items within a tool has relevance
    - A small number means that potentially important areas may have been excluded
    - A large number makes the tool difficult to accurately complete

A final observation is that the use of a checklist or tool suggests that there is no room for the development of further understanding in this specific area or for a new hypothesis to emerge. The use of a descriptive analysis of language, tone, body language and movement may yield information that had not been included as part of the development of the tool, and contribute to an improved understanding of the concept of individual teaming and collective teamwork in the specific situation under study.

6 Research Methodology

The aim of this chapter is to provide an introduction to aspects of research that apply to this thesis. The description of research methodology aims to clarify the language of research relevant to this thesis to provide a contextual overview of research in healthcare and education, and then to further define terms that relate to the research of a specific area of professional practice. Professional Practice can be considered here both as the clinical practice within paediatric healthcare that the simulation aims to 'simulate', as well as the professional practice of educating using simulation techniques. The description of methods will then describe the search methodology used in the literature review and the formal observation of two specific simulation sites in Boston, USA and London, UK.

6.1 Research and its classification

A broad definition of the term research is to describe the gathering of data, information and facts for the advancement of knowledge. It encompasses a range of activities from methodologically rigorous scientific study to the search for information on the World Wide Web. In the context of scientific study the research can be classified according to area of study (eg genetics, anthropology), the methodology employed (eg linkage analysis of genetic research, epidemiology) or the type of data or information collected (eg quantitative or qualitative) (Tavakol & Sandars, 2014a, 2014b). It has sometimes been written that the aim of research is to either accept or reject a hypothesis or an answer to a specific question. This is certainly one possible aim and is illustrated by the double blind randomized trials in healthcare in which the effect of a specific intervention, such as a pharmaceutical agent, is tested. However the term research is also appropriately applied to studies where there is not a clear specific research question. These studies include those often used within ethnography (research into groups of people) that is a type of anthropological research (study of humanity). Ethnography was originally used to describe research into different population groups but can also be used to describe research into professional practice groups.

6.2 Qualitative and Quantitative

The collection of objective quantitative data in clinical studies has historically been held up as the gold standard within clinical medicine. These studies utilise objective numerical measurements and their statistical or mathematical analysis. They include epidemiological studies that aim to describe clear associations, and clinical intervention studies such as the double-blind trial, which aim to provide unequivocal answers to specific clinical questions. Qualitative research describes research that is exploratory and descriptive. In the past this was often criticized as being an area of research with a significant subjective component, but with the development of the methodology and an increasing scientific understanding of human behavior, it is becoming more widely accepted within the scientific community. Qualitative research aims to contribute to an improved depth of understanding and to develop ideas or new hypotheses. It has been extensively used in the social sciences, including education, and its value is increasingly now understood within healthcare.

6.3 Mixed Methods

Healthcare and education within healthcare are both complex dynamic processes and it is often useful to utilize the complementary processes of quantitative and qualitative research methodology. The term "mixed methods" refers to the methodology of research that advances the systematic integration, or "mixing," of quantitative and qualitative data within a single investigation or sustained program of inquiry. This mixed methodology permits a more complete and synergistic utilization of data than does separate quantitative and qualitative data collection and analysis. This methodology originated in the social sciences and has recently expanded into the health and medical sciences in the last decade, its procedures have been developed and refined to suit a wide variety of research questions. These developments include advancing rigor, offering alternative mixed methods designs, noting research questions that can particularly benefit from integration, and developing rationales for conducting various forms of mixed methods studies.
The core characteristics of a well-designed mixed methods study includes the following:

1. Collecting and analysing both quantitative (closed-ended) and qualitative (open-ended) data.
2. Using rigorous procedures in collecting and analysing data appropriate to each method's tradition, such as ensuring the appropriate sample size for quantitative and qualitative analysis.
3. Integrating the data during data collection, analysis, or discussion.
4. Using procedures that implement qualitative and quantitative components either concurrently or sequentially, with the same sample or with different samples.
5. Framing the procedures within philosophical/theoretical models of research, such as within a social constructionist model that seeks to understand multiple perspectives on a single issue—for example, what patients, caregivers, clinicians, and practice staff would characterize as "high quality treatment".

6.4 Literature Review

A review of the literature is an essential part of the development of a research proposal and may also form the main data collection method in some areas of research. There are several specific types of review which include a methodologically rigorous meta-analysis of published results, systematic review with clear criteria for inclusion and exclusion, the more common traditional or narrative review that uses specific overarching concepts to guide the use of search engines or databases, and an integrative review in which the search is complemented by new information from original research. The review used in this thesis is predominantly narrative but is integrated with new information in the final chapter.

6.5 Professional Practice

The meaning of the individual terms 'Practice' and 'Professional' as well as the concept of Professional Practice have been explored by Bill Green in his book 'Understanding and Researching Professional Practice (Green, 2009) and Joy Higgs in her book Health Practice Relationships (Joy Higgs, 2014). A definition from this second book is:

“The enactment of the role of a profession or occupational group in serving or contributing to society”

The term ‘practice’ within this thesis predominantly refers to the practice of simulation education within the healthcare professions. The term ‘health care professions’ (with an s) is a deliberate one as the intention is to describe interprofessional approaches to simulation education. These professions could include any that have a role in acute care paediatrics such as social workers, physiotherapists, administrators, dieticians, medical radiation technicians and speech and language therapists. It is likely that specific professions such as medical and nursing will be overrepresented in view of the subject area being one in which they both have a significant clinical role; that of effective teamwork while caring for a child that is acutely critically ill.

Both practice and learning can be considered as distinct social phenomena that are continually evolving and influenced by factors both internal and external (context) to the individual but practice is not grounded as clearly within theoretical constructs as education and learning are. ‘Practice’ is a term that may mean different things to different people and is often used in a pragmatic sense – ie a sensible and realistic conceptual understanding of what practice means in reality (Green, 2009). An individual’s perception of their own and others’ professional practice is influenced by their previous experience and consequent interpretation, and that perception is then shared using language and communication patterns that may be specific to the professional group.

It is reasonable in light of the purpose of this thesis to attempt to unravel and clarify some features of professional practice:

- The term ‘professional’ implies a standard in and of itself. This standard may have generic criteria that apply across all professions as well as those that are profession-specific.

- There is a close relationship between the terms ‘ethical’ and ‘professional’ and professional practice in healthcare certainly encompasses an ethical component.
- The Practice of Simulation Education within healthcare would imply the practice of simulation within an educational construct as well as a healthcare construct. This is an important concept, as there may be a belief that the ability to practice healthcare implies an ability to practice simulation education in healthcare.
- ‘Professional’ is also a term that is used in contrast to the term amateur. This may raise questions about what defines an amateur or professional educationalist. Developing professional practice in simulation education may require formal education, assessment and accreditation as well as experience.

6.6 Researching Professional Practice

The aim of research into professional practice is to provide theoretical and practical evidence that ultimately leads to an operational strategy to improve that practice. This requires the interpretation of the theoretical and practical information collected to contribute to theoretical frameworks. The perspective of someone who is recognized as a practitioner within this area may add further credibility to this interpretation. The practitioners’ own experience and familiarity with the subject area creates the background theoretical framework to the proposed area of research. This enables questions to be focused on aspects of the framework that are absent or require further evaluation in different contexts.

A researcher in professional practice needs to possess an ability to frame and analyse information as objectively as possible within an evidence-based framework as well as to be able to openly discuss their own assumptions and personal biases that may influence their interpretations. In researching with colleagues, this necessitates mature and articulate communication abilities to enable the individual researchers as well as the research group to remain open minded to the development of new research strategies and interpretations. In this research project I worked as an individual researcher, but had multiple interprofessional interactions with other colleagues, either working in or researching related areas of professional practice.

The research methods involved in the ethnographic study of professional practice may include direct or indirect observation of the professional practice under study, use of a questionnaire or the interviewing of practitioners either individually or together. A combination of these methods may provide triangulation of the data and improve the validity of the results. The use of observation and interviewing are expanded on below as these were the methods used in this research:

6.7 Observation of Practice

The method of observation is predominantly a qualitative research methodology that provides information on a sociocultural context, organization, processes and relationships. Research observers of professional practice may begin their observations with minimal preconceptions or knowledge of the practice under question and rely on their observational skills to develop emergent themes. Alternatively they may begin with both knowledge and experience of the area under study when the developing emergent themes are likely to be influenced by the observer's own professional experience. In addition the observations may be conducted by individual researchers or by a group of observers. The latter situation is likely to minimize the biases of individuals within the results but requires some validation of inter-rater reliability as well as intra-rater reliability over time.

It is important to be aware of the degree of researcher participation within the processes and activities being observed and this has been classified or graded by a number of experts in the field. A simple classification system of use within this research is that below by Raymond Gold (Gold, 1958).

- Complete participant
    - Researcher is embedded within the processes while documenting observations
- Participant as observer
    - Researcher actively participating in processes while documenting observations

- Observer as participant
    - Researcher passively participating in processes while documenting observations
- Complete observer
    - Researcher observing and documenting processes but not actively or passively participating within the processes under study

There is an argument that participant observers may be biased by their previous experiences but an alternative view is that the 'signal to noise' ratio may be greater, that is the participatory observer is likely to focus on aspects already known to be relevant both from their own practice and their knowledge of the literature, and have the ability to filter out confounding information (or 'noise') (Higgs & McAllister, 2007).

The process of observation involves the documenting of detailed field notes and the content of these notes is obviously guided by the research aims or question, but until the observation has begun it is not always possible to entirely predict what the observation should focus on or include (Merriam, 1998). Documentation of observations has been categorised as descriptive or selective. 'Descriptive' refers to the collection of all information observed, and 'selective' to the concentration on specific social relationships, activities or processes. A third term 'focused' has also been used to describe observation supported by interviews that use insights of the participants to guide subsequent observation, which further reinforces the evolving philosophy of this type of research. An alternative with both participatory and non-participatory observers is to provide an observation tool that provides a framework for the observation but also allows for emergent themes.

6.8 Interviewing and conversation

'Interviewing' has traditionally been the term used when data or information on theoretical and practical constructs has been gained in face-to-face verbal communications. In a similar way to the classification of observation processes, interviews have been categorized as:

- Structured (Firman, 2008) (also known as a researcher administered survey)
    - This type of interview aims to collect very specific data in a similar way to a written survey. The questions are presented to each interviewee in an identical way and there is minimal flexibility, although some open questions may be included. The information collected therefore conforms to predetermined themes.
- Semi-structured (Ayres, 2008)
    - The concept of the semi-structured Interview is an interview in which the processes lie between that of the structured and unstructured interview. The interviewer generally has a framework of themes to explore but has the flexibility to be guided by the interviewee towards new areas or themes.
- Unstructured (Firmin, 2008)
    - This describes a non-directive interview where the topic is clear but the aim is that the interviewee determines the way in which the conversation goes. Follow up questions from the interviewer aim merely to probe or clarify.

The concepts of 'passive' and 'active' interviewer can also be used and these terms can be seen to have a relationship to the terms complete observer (passive) and complete participant (active) used when considering observation. The aim of the passive interviewer is to collect specific information in a similar way to that collected using a written survey. An active interviewer has more flexibility in what information is collected. There is a very valid argument that no interviews can be entirely passive as the mere presence of an interviewer provides a social interaction and will actively change some responses by the interviewee.

The unstructured or active interview can be considered as having a significant overlap with conversation and the term discourse analysis has been used to describe information obtained from a conversation. Participant observers commonly gather data through casual conversations, in-depth, informal, and unstructured interviews, as well as formally structured interviews.

7 Description of Methods

7.1 Choice of Methodology

A mixed methods approach was used in this research project that can be divided into two areas:

1. Narrative Literature Review of the use of Interprofessional Simulation that incorporates the concepts of Teamwork or Crisis Resource Management in Postgraduate Pediatric Acute Care Scenarios.
2. Focused observation and interview at two Pediatric Intensive Care Centres that have received international recognition for their simulation training: Boston Children's Hospital and The Royal Brompton Hospital London

The predominant method is qualitative with a thematic analysis of the relevant literature that is expanded by non-participant observation. This is also informed by quantitative data such as the cost of implementing a clinical simulation program. Although a review of published literature is a method that is recognized to provide evidence-based information in the area being studied, the information obtained may not be entirely objective and is subject to bias. Two possible sources of this bias are the authors of the paper and the journal in which it is published. In reporting their research, the authors have some significant input into the way in which they report their research, such as what information has been included, or perhaps more importantly excluded, and the journal is subject to publication bias. Publication bias refers to the fact that research that shows a positive result is more likely to be published.

The recognition of the contribution of a literature review together with its limitations was one of the factors that precipitated a mixed methods review to be used in this thesis. The direct observation of examples of practice of two simulation programs that have contributed to the literature together with the opportunity to ask questions of those involved provided clarification of some of the information published as well as new information. This information may be subject to the biases of the individual observing and reporting, but open minded observation by someone embedded in simulation education is a useful research methodology, as described above.

7.2 Literature Review

In this thesis the intention was not to do a systematic review but a robust narrative review to provide details of a wide range of articles that could be explored in more detail to provide qualitative data, using a thematic analysis, and quantitative data. The aim of the review was to contribute to the development of the following:

- Identification of the levels of evidence (according to Kirkpatrick's model) in support of effective interprofessional teamwork training using simulation in acute care paediatrics.
- Further development of a theoretical educational construct to inform the process of the development of a simulation program, even if the evidence is not yet robust.
- The development of a strategy for the observation of practice in the international centres.
- Identification of gaps within the literature that require further study

The initial aim was to review published literature that described educational interventions, which focused on teamwork or crisis resource management during the interprofessional simulation of an acute deteriorating paediatric patient. It was soon apparent that the use of the term 'deteriorating patient' significantly limited the amount of information that would be available to develop themes and to provide an evidence base for the development of a Paediatric Simulation Program. Consequently the review was expanded to include literature that referred to the interprofessional simulation of pediatric resuscitation (European and Australasian terminology) or an acute code (USA terminology), the hypothesis being that there was significant overlap in the components of teamwork or crisis resource management required in both a deteriorating patient and a patient who has suffered an arrest (most commonly respiratory arrest in the paediatric population).

7.2.1 Database Search

The two databases that were chosen for a structured literature search were:

- OVID (medline)
- CINAHL

The search terms were informed by the title of this research that is repeated below:

> 'Postgraduate Simulation within a Hospital Setting with a focus on Crisis Resource Management and Inter Professional Team Training in Acute Care Paediatrics: Where are we and where should we be?'

The help of an experienced Academic Student Support Librarian was sought to ensure a rigorous development of search terms that were optimized on the basis of the database structure that was being accessed. This involved identifying key concepts as search criteria that were:

- Simulation, including manikins and models
- Interprofessional / multiprofessional
- Teamwork, communication and collaboration
- Emergency / critical care
- Paediatrics / Pediatrics, including children and infants

A number of different searches were done in order to identify a search that was most effective in identifying articles thought to be of relevance. A preliminary search was done in March 2015 and this was repeated prior to completing the final analysis in August 2016. The results (numbers of articles) are from this final search and the analysis and write up includes all articles published up until the end of 2015. The search terms for each database used are shown in the tables below and the CINAHL search excluded those articles that would already have been identified by OVID Medline:

Table 2 OVID Medline Search Strategy

	Term	No of Refs
1	Manikins	3922
2	Mannequin*tw	1213
3	Manikin*tw	2096
4	Patient Simulation	3853
5	(simulat* (infant* or child* or paediat* or pediat* or train* or teach* or educat*)).tw	15883
6	Models, Anatomic	5807
7	model*anatomic*.tw.	87
8	vignette*.tw.	7437
9	Or/1-8	34723
10	Pediatric/ed {Education}	6622
11	Pediatric Nursing/ed {Education}	2027
12	(paediatric* or pediatric*).ti	130248
13	Ed.fs	241175
14	(educat* or train* or teach*).ti	276825
15	12 and (13 or 14)	276825
16	10 or 11 or 15	11364
17	Patient care team/ or hospital rapid response team	57582
18	(team* or collaborat* or cooperat*).tw.	315070
19	17 or 18	350506
20	9 and 16 and 19	100
21	Exp Intensive Care Units, Pediatric/	16669
22	Critical Care	44273
23	Emergency medical services/ or advanced trauma life support care/ or	85717

	emergency medical service communication systems/ or emergency service, hospital/	
24	crisi.tw	38410
25	rapid response.tw	4156
26	emergenc*.ti	86583
27	resuscit*ti	21968
28	Or/21-27	253150
29	9 and 28	2425
30	20 and 29	2471
31	(paediatric* or pediatric* or infant* or child* or neonat*).tw	1625760
32	29 and 31	521
33	20 or 32	567
34	**Limit 33 to English language**	**539**

Table 3 CINAHL Search Strategy

	Term	**No of Refs**
1	(MH "patient Simulation") OR (MH "Vignettes") OR (MH "Simulations")	13,232
2	(MH "Models. Anatomic")	3,326
3	TX manikin* OR mannequin*	1,971
4	TI simulat*	7,413
5	AB model* anatomic*	176
6	TX vignette	11,196
7	S1 OR S2 OR S3 OR S4 OR S5 OR S6	26,127
8	(MH "Pediatrics / ED")	884
9	(MH "Pediatric Nursing +/ED")	1,184
10	TI (Paediatric* OR pediatric*) AND TI	1,371

	(educ* OR train* OR teach*)	
11	S8 OR S9 OR S10	23,011
12	(MH “Multidisciplinary Care Team”)	25,186
13	TI (team* OR collaborat* OR cooperat*)	27,205
14	AB (team OR collaborat* OR cooperat*)	67,790
15	S12 OR S13 OR S14	102, 306
16	S7 AND S11 AND S15	29
17	(MH “Intensive care, Neonatal”) OR (MH “Neonatal Intensive Care Nursing”)	5,270
18	(MH “Emergency Service+”)	30,592
19	(MH “Emergency Care”)	17,886
20	(TI (crisis OR emergenc*)) OR AB rapid response	39,316
21	S17 OR S18 OR S19 OR S20	72,544
22	S7 AND S21	1,079
23	(paediatr* OR pediatr* OR infant* OR child* OR neonat*)	449,167
24	S2 AND S23	256
25	**S16 OR S24 (excluding Medline records and limited to academic articles) (106)**	**57**

The titles of the articles identified by the OVID and CINAHL searches were read and those that referred to papers outside the scope of this review were discarded. The abstracts of the remaining articles were read in full and the journal was accessed if the abstract contained the key concepts of the initial search criteria alluded to above.

7.2.2 Secondary Search

Following the identification of articles using the primary database search, the bibliography of each ***relevant*** article was reviewed and additional papers thought to be of interest identified. The abstracts of these articles were read in full in a similar way to above and the journal was accessed if the abstract contained the key concepts of the initial search criteria alluded to above.

All of the identified papers to be included in the structured review were entered into an Endnote library for referencing.

7.3 Thematic Analysis

During the initial reading of each of the papers describing original research text was highlighted to indicate those areas that reflected the topics of interest identified from the review articles or a new topic of interest. Once all the papers had been read a Table was constructed (Appendix ii) that was populated with details of these papers, including authors, some characteristics of the sessions and number of participants. This Table provided an initial overview to guide the repeat reading of papers to clarify points. Each paper was then reread and index cards were used to separately document information that included the previously highlighted topics as well as areas of similarity and differences between the described educational interventions. Each paper together with its associated index cards was assigned a number to allow cross checking of information between the paper and each card. The text on each index card was unique to one specific paper. This was done in a random order and the allocated number was added to the Table of original papers (Appendix ii). In constructing the categories and sub categories and ultimately themes the index cards could be organized into groups with similar constructs. The use of the index cards enabled flexible classification and reclassification of the topics of interest as the thematic constructs were developed.

7.4 Non-Participant Observer Visits

The two simulation programs that I arranged to visit were:

- SimPeds at Boston Children's Hospital, Boston, USA
- SPRinT at The Royal Brompton Hospital, London, UK

These centres were chosen because of their excellent reputations as well as the relationship that existed between some of their faculty and myself; I had received my initial Simulation Instructor Training at SimPeds in Boston in 2008 and was introduced to the SPRinT team at the International Pediatric Simulation Society Conference in Vienna in 2014.

Information is increasingly recognized as being available on the internet and in many instances easily accessible by members of the public. It was felt to be useful to access information with direct relevance to the two simulation programs that were to be visited. This included material available on the following websites:

- http://ipssglobal.org/
- http://simpeds.org/
- http://sprintsimulation.co.uk/

A brief introduction to the clinical context of Boston Children's Hospital and The Royal Brompton Hospital is given here.

7.4.1 Boston Children's Hospital

Boston Children's Hospital is a 404 bed Children's Hospital with specialist departments that range from neonatal to adolescent. The hospital has over 25, 000 admissions per year (http://www.childrenshospital.org/about-us/locations/boston). It was voted the best Children's Hospital within the United States in 2015. The Department of Critical Care oversees the Paediatric Intensive Care Units. There is a 30 bed Medical Surgical Intensive Care Unit and a 12 bed Medicine Intensive Care Unit.

There is access to theatres, cardiac catheterization and extracorporeal membrane oxygenation facilities.

7.4.2 The Royal Brompton Hospital

The Royal Brompton Hospital is one of the hospitals administered by the Royal Brompton and Harefield Trust and cares for both adults and children.
It is located in London and has 312 beds with 2200 staff (http://www.rbht.nhs.uk/about/our-work/brompton). It has an international reputation for treatment of heart and lung disease and has a 20 bedded Paediatric Intensive Care Unit as well as a Paediatric Cardiorespiratory Ward that can take up to 40 paediatric patients. There is access to operating theatres, cardiac catheterisation and a sleep laboratory.

7.4.3 Preparation for the visits

One of the aims of the literature review was the development of a focused strategy for the observation of practice in the international centres.

At the time of the visits the literature review was underway but had not been completed. Categories and sub-categories were beginning to be identified but the final themes had not yet been developed. Consequently the categories and sub categories, as well as personal experience of simulation, were used to produce 'trigger areas' that aimed to guide conversation with members of the PEDsim and SPRinT faculty. These included:

- Simulation Program
- Simulation Faculty
- Teamwork or CRM Courses
- Interprofessional principles
- Challenges
- Evidence of effectiveness

The visits were planned for February and April 2015 following consultation with Professor Peter Weinstock in Boston and Lydia Lofton in London. Verbal consent for the visits and for the use of material in this thesis was obtained. The aim of the visits was to observe an educational simulation session as a non-participant observer and to also have the opportunity to ask questions to clarify points from the literature and obtain further details regarding the strategic development and operationalization of their own simulation programs.

7.5 Ethical Approval

The Human Ethics Committee of the University of Canterbury granted ethical approval reference number HEC 2015/04/LR. The full application is provided within the appendix (Appendix v) as well as a copy of the letter confirming approval (Appendix vi).

8 Results

This chapter is divided into two main sections: The first section describes the results of the literature review. This begins with a description of the numbers of papers identified in the primary and secondary searches. These were then read and characterized regarding aspects such as type of paper, country of origin and size of study. Quantitative data of relevance was extracted before a thematic analysis was done. The second section gives details of the simulation programs that were visited using information from the internet that was available prior to the visits and elaborates on this using information obtained during the visits.

8.1 Literature Review

One of the original aims was to include only papers that adhered to the CAIPE definition of interprofessional education. However in many cases the faculty member (s) publishing the paper appeared to come from one specific profession (usually medicine) and it was not always clear whether other professions contributed to the design and implementation of the initiative. As a result papers in which the participants were interprofessional were included regardless of the profession of the faculty or authorship.

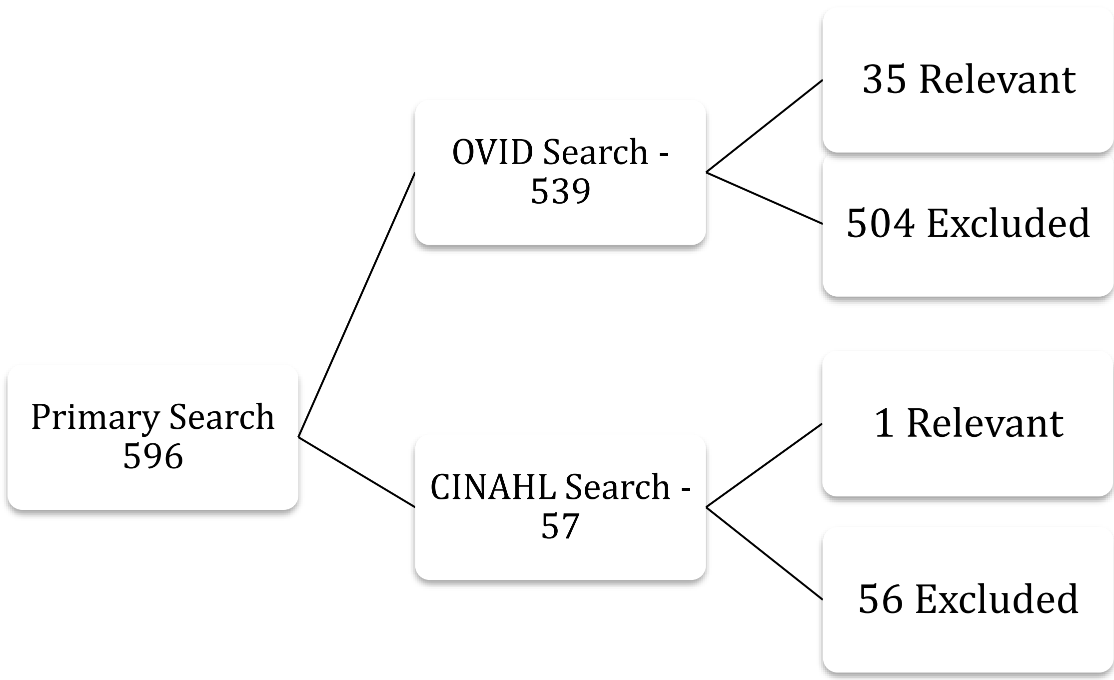
8.2 Paper Identification

A total of 645 papers were identified in the Primary Search of the OVID Medline and CINAHL databases. The abstracts of each of these articles were reviewed and the full paper was downloaded as part of the literature review if the abstract confirmed that the paper met the key conceptual inclusion criteria (presented again below):

- Simulation, including manikins and models
- Interprofessional / multiprofessional
- Teamwork, communication and collaboration
- Emergency / critical care

- Paediatrics / Pediatrics, including children and infants

Figure 8: Numbers of papers included and excluded from database searches



This Primary Search identified a total of 36 articles. A further 12 articles were identified as part of the Secondary Article Search. The 48 identified papers included 17 review articles and 31 describing original research.

The main exclusion criteria for papers that were identified from the abstract as being potentially of relevance were:

- Participants were undergraduate health professionals.
- Initiative aimed at one profession only.
- Research described the development of a teamwork tool rather than the piloting or validation of the tool in the clinical context.

8.3 Characteristics of Papers

As this review was not conducted using strict systematic methodology there were significant differences in the research background of each paper and this is elaborated on below. In addition it was felt useful to document which country the work originated from in view of the differences between the organisation of healthcare in different countries and this was included within the Table of Original Research (Appendix ii):

8.3.1 Research methodology

The review articles were separated from the other papers and a Table was constructed to include the title of the review, authors and the main points discussed (appendix iii). These articles were used as a reference for current expert opinion within this area of study. They provided a broad foundation of topics of interest that helped guide a framework for the observational work and their bibliographies contributed to the secondary search. Two of the articles were included in the thematic analysis as they provided details of specific educational interventions (D. J. Grant & Marriage, 2012; Svavarsdottir & Brattebo, 2013). The remaining 15 were excluded from the thematic analysis.

The majority of the papers describing original work discussed either the effect of a planned single educational intervention using simulation or an ongoing simulation program. The Table in appendix i contains details of all of these papers, as well as the review papers, for reference and includes a summary of their results.

8.3.2 Country and Hospital Department

The majority of publications are from the United States of America (USA). There are no articles from New Zealand although one article is from Sydney Australia (O'Leary et al., 2014). The American Health System is predominately a private or Insurance based healthcare system for both Hospital and Primary Care in contrast to a predominantly publicly funded system in New Zealand. The Australian system has some areas of commonality with the USA and NZ systems.

The two paediatric departments that are leading research in the area of interprofessional team-training and simulation in the USA are the Paediatric Intensive Care Units and the Emergency Departments although work has also been done specifically in Primary Care and Rural Hospitals (J. L. Kennedy et al., 2013) (Toback, Fiedor, Kilpela, & Reis, 2006).

8.4 Quantitative Data Identified

Although the main focus of this research was to use qualitative methodology, the literature review did reveal some quantitative information that is not analysed as part of the thematic analysis.

8.4.1 Number of participants and simulation episodes

In estimating the evidence for educational initiatives in interprofessional simulation based learning it is reasonable to consider two aspects regarding the published research:

- The number of participants within the study
- The frequency of simulation episodes
- The number of simulation episodes that each individual or team were exposed to within the study

This information was not easily accessible in all of the papers but where available the number of participants is included in the table in appendix ii. The maximum number was 596 (Wheeler, Geis, Mack, LeMaster, & Patterson, 2013) and the minimum was 22 (Nwokorie, Svoboda, Rovito, & Krugman, 2012) where the 596 individuals participated over 20 months (30 individuals per month) and the 22 over 3 months (just over 7 individuals per month). In those papers where regular training was established, the frequency of simulation episodes conducted by the faculty varied between 90 simulations over 1 year (7.5 per month) (Patterson, Geis, Falcone, LeMaster, & Wears, 2013) to one session per month (Andreatta, Saxton, Thompson, & Annich, 2011; Auerbach et al., 2014;

Zimmermann et al., 2015). The number of simulation episodes experienced by each individual or team also showed significant variability; this was partly influenced by whether the simulation episode was as part of a structured educational course or an In-Situ experience that could be repeated. The maximum number of simulation episodes experienced by individual practitioners that was explicitly reported was 10 (Theilen et al., 2013). In some papers the number of learning encounters was also quantified and this referred to the number of participants multiplied by the number of sessions (P. H. Weinstock et al., 2005).

8.4.2 Cost of establishing a Pediatric Simulation Program

One of the aims of this literature review was to inform the development of a simulated interprofessional education curriculum within a large healthcare organisation. Information about the cost of such an important intervention is critical.

The costs of establishing a Hospital wide Simulation Program are obviously significantly more than those associated with a departmental program and these have been well documented by the simulation Team from Boston Children's Hospital (P. H. Weinstock, Kappus, Garden, & Burns, 2009; P. H. Weinstock et al., 2005). These costs can be categorized as 'start up' or 'capital' which include those associated with the purchasing of manikins and alteration of physical space as well as the operational costs of ongoing personnel and equipment resources required to run the program. A significant part of the ongoing costs is the salary of personnel. Table 4 shows the capital and initial operational costs of hospital-wide and Departmental simulation programs in Canada and the USA as published.

Table 4: Examples of capital and operational costs associated with simulation programs

Hospital / Country	Year	Capital Costs Country of origin/ NZ $	Operational Costs Country of Origin / NZ $
USA (P. H. Weinstock et al., 2005) ***Pediatric Hospital Program***	2005	$290, 000 (included physical site construction) / NZ$406,000 (at 1.4 exchange) $180, 000 (second mannequin) / NZ$252, 000 (at 1.4 exchange)	$68 000 per year with coordinator salary included / NZ$95,200 per year ($560 per month or $44 per trainee / NZ$784 per month or NZ$61.60)
USA (Calhoun, Boone, Peterson, Boland, & Montgomery, 2011) ***Pediatric Hospital Program***	2011	$129,000 (included all equipment, installation and faculty training) / NZ$180,000 (at 1.4 exchange)	$11,695 per year including warranty and maintenance but no salary ($974 per month or $14 per trainee) / NZ$16,373 (NZ$1,363 per month or NZ$19.60 per trainee)
Canada (Mikrogianakis et al., 2008) ***Pediatric Department Trauma Initiative***	2008	$11, 000 / NZ$11,660	$1,200 per year but no salary included ($100 per month) / NZ$1,272 (NZ$106 per month)

There are a variety of funding models and the original published costs of two of these are illustrated in the table above; one model is to minimize personnel costs by redefining the role of clinical educators towards a specific educational simulation role such that the costs continues to be met by their department and not the simulation program (Calhoun et al., 2011). In this model there are no fulltime clinical or managerial staff and a further consideration is that high level equipment warranties are mandatory in view of poor technical support. These considerations are likely to limit the potential size of the program as well as its sustainability. The more common model is to initially have a program coordinator with technical staff who may be partially funded by the program and clinical educators who are funded by their department (P. H. Weinstock et al., 2005). This staffing model obviously adapts as the simulation program becomes embedded.

8.5 Thematic Analysis

The identified articles could be subdivided into general review articles, two of which included a review of an established simulation program (D. J. Grant & Marriage, 2012; Svavarsdottir & Brattebo, 2013) and articles describing original research. The review articles were read first to identify areas that were considered important by recognized experts in the field and to provide a conceptual framework on which to scaffold the thematic analysis. The main thematic analyses followed a detailed review of the methods, results and conclusions of the articles describing the original research.

8.6 Review Topics of Interest

The 17 review articles provided a concise overview of the topic of this thesis and the organization of information provided the following broad areas of interest:

- Educational theoretical principles
- Historical changes in clinical education:
- Improving patient safety
- Technical skills and Non technical skills
- Interdisciplinary collaboration
- Communication
- Teamwork and Crisis Resource Management
- Resuscitation Training

- Faculty Training
- Assessment

8.7 Development of Themes

The 31 articles describing original research were predominantly descriptive and based on prospective or retrospective analysis following an isolated or ongoing educational innovation. There were 2 articles reporting on randomized controlled trials specifically looking at the effect of incorporating In-Situ simulation into the recertification of paediatric resuscitation (Kurosawa et al., 2014) and comparing high and low fidelity simulation and techniques of debriefing (Cheng et al., 2013).

There was a significant amount of repetition in the descriptive studies but in view of the small number it was decided to review all studies even though thematic saturation is likely to have been reached with fewer numbers.

The five thematic constructs that emerged were:

1. Orientating to resilience: A continuous audit
2. Simulation: Within the curriculum and continuum of education
3. Teamwork: defining and evaluating
4. Evaluation: Intervention and self assessment
5. Service Development: Embedding resilience

Each of these themes is discussed in more detail in the following sections.

8.7.1 Theme 1: Orientating to resilience

Resilience is a term that is increasingly used to describe both individual personal characteristics as well as organizational characteristics within the quality and patient safety literature. A resilient organization is defined as:

‘an organization that anticipates, prepares for, responds and adapts to incremental change and sudden disruptions in order to survive and prosper’

The term ‘orientating to resilience’ was used to encompass the concept of an organization that was aware of its error profile and the specific needs of it’s staff: Formal needs assessment of the Hospital or Staff involved prior to clinical simulation training was observed (Zimmermann et al., 2015) but was rare. Questionnaire-based surveys were used to identify simulation experience and specific simulation interests (Deutsch, Olivieri, Hossain, & Sobolewski, 2010). An assessment of the safety climate or knowledge of safety issues of the candidates attending a simulation course was accomplished in one study using a validated tool and pretest prior to the simulation (Patterson, Geis, LeMaster, & Wears, 2013). In the same study consultation with patient safety experts was also described (Patterson, Geis, LeMaster, et al., 2013).

Local patterns of adverse events were used in some studies to inform the development of the simulation scenarios (Patterson, Geis, LeMaster, et al., 2013; Stocker et al., 2012). An alternative method was to use those areas of need identified within the literature (Andreatta et al., 2011; Auerbach et al., 2014; Hunt, Walker, Shaffner, Miller, & Pronovost, 2008). The involvement of experienced clinical staff as educational faculty with an interest in patient safety and simulation was common and the clinical content of the scenarios was often based on real patients or recent clinical encounters and incorporated conditions common in the paediatric population (Falcone et al., 2008) (Andreatta et al., 2011).(Auerbach et al., 2014; O'Leary et al., 2014; Svavarsdottir & Brattebo, 2013; Volk et al., 2011; Wheeler et al., 2013) (Couto, Kerrey, Taylor, FitzGerald, & Geis, 2015).

The explicit identification of latent errors as contributory factors to patient safety was a recognised outcome in several articles (Bishop-Kurylo & Masiello, 1995) (Hunt, Heine, Hohenhaus, Luo, & Frush, 2007; Hunt et al., 2008) (Geis, Pio, Pendergrass, Moyer, & Patterson, 2011) (Patterson, Geis, Falcone, et al., 2013; Patterson, Geis, LeMaster, et al., 2013) (O'Leary et al., 2014; Wheeler et al., 2013) (Zimmermann et al., 2015) and was particularly common during the ‘In-Situ’ simulation interventions. The precise categorisation of these errors varied according to the objectives and tools of the study; these included the adherence to institutional and trauma management protocols (Hunt et al., 2007) as well as equipment, medication, resources and system related errors (Wheeler et al., 2013). This was explicitly fed back to the leaders of patient safety of the organization in one study (Wheeler et al., 2013). In another study the scenarios themselves contained equipment malfunctions and deliberate medical error based on either clinical experience or referred by the leaders of patient safety (Patterson, Geis, Falcone, et al., 2013).

The area of teamwork is discussed below but it is useful to note here that there appeared to be two different philosophies in the identification of active errors that occurred within the scenarios; individual or team based. Individual errors were generally classified as a knowledge gap (e.g a procedure being performed incorrectly) (Geis et al., 2011) or performance gap when compared to key clinical and CRM competencies (D. J. Grant & Marriage, 2012). The assessment of active errors with reference to team functioning was considered using an analysis of the tasks that needed to be completed (Hunt et al., 2007), the time taken for crucial technical skills to be performed (Hunt et al., 2008) or probable causation factors contributing to suboptimal care (O'Leary et al., 2014). In this latter study the three most significant causation factors were loss of situational awareness, communication failures and knowledge deficits.

The reclassification of an active error into a latent error was demonstrated in a study from Cincinnati (Hunt et al., 2008); concerns about omission of an independent double check of medication during an acute scenario were raised during debriefing but the omission recurred during the subsequent scenario. Further exploration during debriefing clarified the underlying cause of this observation which was that the medication nurses were being asked to do an unreasonable number of tasks in a short time frame. This demonstrates an active error area being reclassified as a system or latent error. This factor was also identified as important in a simulation aimed at assessing a new healthcare facility and healthcare teams (Geis et al., 2011).

Three studies demonstrated unequivocal evidence of an improvement in patient care with a reduction in both mortality and morbidity and enhanced timeliness or efficiency of care (Andreatta et al., 2011) (Theilen et al., 2013) (Patterson, Geis, LeMaster, et al., 2013). This will be elaborated on in theme 5 below.

8.7.2 Theme 2: Simulation: within the curriculum and continuum of education

This concept refers to the embedding of simulation within training programs rather than it being a stand-alone initiative. This theme is subdivided into the following areas:

- Developing a curriculum, aims and objectives
- Faculty Training
- Knowledge
- Characteristics of simulation ***session***
- Characteristics of simulation ***scenario***
- Debriefing

Developing a curriculum, Aims and Objectives

The development of an explicit patient safety curriculum was referred to in some studies (P. H. Weinstock et al., 2005) (Andreatta et al., 2011; Kotsakis, Mercer, Mohseni-Bod, Gaiteiro, & Agbeko, 2015). This should be created with reference to educational curriculum development principles and this was described in detail in an article from Switzerland (Zimmermann et al., 2015). This strategy was also described in the paper by Grant (D. J. Grant & Marriage, 2012); The Royal College of Paediatrics and Child Health (RCPCH) in the UK published a revised curriculum for medical trainees in 2007 which incorporates aspects aimed at patient safety and the Bristol Paediatric Simulation Programme initially developed their level 1 course to meet those competencies felt difficult to assess in routine clinical practice (D. J. Grant & Marriage, 2012). Their level 2 Simulation Programme that focuses on crisis resource management was developed in a similar way. The extent to which other studies included in the reviewed literature have demonstrated a formal needs analysis or link with an organisations' patient safety profile to inform a patient safety curriculum has been discussed under Theme 1 (8.7.1).

Faculty Training

It has already been mentioned that it was not always clear whether faculty were themselves role modeling the interprofessional approach although there were references to faculty from nursing and medicine in some papers (Hunt et al., 2007) (Allan et al., 2010) (Cheng et al., 2013) (Auerbach et al., 2014; Kurosawa et al., 2014; O'Leary et al., 2014) (Kotsakis et al., 2015). The commonest criteria that were referred to in faculty was that they were clinically experienced and / or instructors in resuscitation life support courses (Cheng et al., 2013) (J. L. Kennedy et al., 2013) (Patterson, Geis, Falcone, et al., 2013) (Patterson, Geis, LeMaster, et al., 2013) (Couto et al., 2015; Kurosawa et al., 2014). The two specific areas where expertise would be particularly valuable are the areas of debriefing and the analysis of teamworking or non technical skills by observation or the use of teamworking tools (Allan et al., 2010) (Geis et al., 2011) (Auerbach et al., 2014; Patterson, Geis, Falcone, et al., 2013) (O'Leary et al., 2014) (Couto et al., 2015; Kotsakis et al., 2015; Nwokorie et al., 2012). However, it must also be noted that the use of scripted debriefing strategy was found to be useful with novice instructors (Cheng et al., 2013).

Knowledge

Inadequate knowledge was highlighted as a concern (Hunt et al., 2008) (Geis et al., 2011). This knowledge included recognition of arrhythmias as well as knowledge of protocols such as resuscitation guidelines (Hunt et al., 2008). One study confirmed inadequate knowledge as one of the three most important factors contributing to sub optimal care (O'Leary et al., 2014).

Knowledge based revision or the introduction of new knowledge, including the principles of CRM, prior to the simulation session commonly occurred in one of two ways; in advance of the simulation session with workshops, online tutorials or pre reading (Falcone et al., 2008; Patterson, Geis, LeMaster, et al., 2013) (Kurosawa et al., 2014) or facilitated study in a tutorial or discussion within the simulation session (Toback et al., 2006; P. H. Weinstock et al., 2005) (Allan et al., 2010) (Volk et al., 2011) (Figueroa, Sepanski, Goldberg, & Shah, 2013; J. L. Kennedy et al., 2013; Stocker et al., 2012) (Cheng et al., 2013) (Patterson, Geis, LeMaster, et al., 2013) (Kurosawa et al., 2014) (Katznelson, Mills, Forsythe, Shaikh, & Tolleson-Rinehart, 2014; Kotsakis et al., 2015) and some studies incorporated both (Patterson, Geis, LeMaster, et al., 2013) (Kurosawa et al., 2014). The incorporation of prework or tutorials within the simulation sessions was most common prior to a planned simulation session within a simulation centre but was a feature of one study using brief just-in-time In-Situ training (Nishisaki et al., 2010). A study from Cincinnati had an alternative approach to the 'just-in-time' approach where the areas of team function and communication were incorporated into a significant number of educational activities in preparation for both clinical service and the simulation session in the preceding year (Falcone et al., 2008).

In most cases the knowledge-based tutorials were held within the simulation session prior to the simulation scenarios. Interestingly in two studies the simulation session was used to highlight gaps in knowledge as a strategy to enhance the motivation to learn (Hunt et al., 2007) (Mikrogianakis et al., 2008). In one of these studies a knowledge workshop was provided following the first scenario and immediately before the second scenario (Mikrogianakis et al., 2008). This showed a significant decrease in participants' self assessment of their own knowledge regarding where to find equipment in the resuscitation room. In the second study of 18 Emergency Departments, an unannounced second scenario (mock code) was conducted 6 months after the educational intervention (Hunt et al., 2007). This showed a significant improvement in the number of ED teams performing the tasks necessary for effective resuscitation of the child. This reflected an improvement in team knowledge and skills that enabled task completion. In a different study, participants' own perception of their knowledge and ability was also described as improving following simulation, specifically in the group of participants that had experienced a resuscitation event prior to the simulation-based training course (Figueroa et al., 2013).

Characteristics of simulation session

On the basis of the published data it was not always clear whether participants had had previous experience in simulation or orientation to simulation prior to the simulated scenario or simulation session. Orientation to the simulation environment and equipment was specifically commented on in one paper as a development that occurred secondary to feedback (P. H. Weinstock et al., 2005) and was explicitly referred to as being part of the session in other studies (Kotsakis et al., 2015; Mikrogianakis et al., 2008; Stocker et al., 2012).

Simulation experiences can be considered as:

- Occurring in a Simulation Centre or In-Situ
- Being announced or unannounced

The majority of educational programs that occurred within a simulation centre contained lectures or interactive workshops, and planned simulation experiences, followed by debriefing with final questions and discussion. The length of these workshops varied from 2 hours (Falcone et al., 2008 {Stocker, 2012 #665; Stocker et al., 2012) (Theilen et al., 2013) (Zimmermann et al., 2015) through 4 or 5 hours (J. L. Kennedy et al., 2013) (Volk et al., 2011) to 9 (Figueroa et al., 2013) (Kotsakis et al., 2015) or 12 hours (Patterson, Geis, LeMaster, et al., 2013). In this latter case the course was subsequently reduced to 4 hours following feedback with no loss of effect. In most of these courses there was the opportunity for further simulation scenario practice within the session that provided an opportunity to practice and develop the areas that were discussed in the debriefing (Falcone et al., 2008; Messmer, 2008; Mikrogianakis et al., 2008) (Volk et al., 2011) (Cheng et al., 2013; J. L. Kennedy et al., 2013) (Kurosawa et al., 2014). In-Situations where there was not the opportunity to practice the skills raised in debriefing, there were sometimes the expectation that the course would be repeated (Allan et al., 2010) or that the course would be followed by In-Situ opportunities to practice (P. H. Weinstock et al., 2005) (P. H. Weinstock et al., 2009) (Geis et al., 2011; Kurosawa et al., 2014; Stocker et al., 2012) (Katznelson et al., 2014) (Theilen et al., 2013).

In a similar way to the simulation centre workshops, the simulation experiences that occurred In-Situ could be planned and announced (Allan et al., 2010) (Nishisaki et al., 2010; Stocker et al., 2012) (Katznelson et al., 2014; Theilen et al., 2013) (Kurosawa et al., 2014)

(Zimmermann et al., 2015) but in contrast they could also be unannounced. In these latter situations participants were usually aware that a simulation was planned (Wheeler et al., 2013) (Auerbach et al., 2014) but this was not always the case and in some situations the team may have thought they were attending an actual emergency (Bishop-Kurylo & Masiello, 1995) (Hunt et al., 2007) (Andreatta et al., 2011; Hunt et al., 2008) (Patterson, Geis, Falcone, et al., 2013; Wheeler et al., 2013) (Auerbach et al., 2014).

A combination of simulation centre and In-Situ sessions was also used during the assessment of new healthcare facilities (Geis et al., 2011) and it was also highlighted in another study that 'the majority of our population had participated in laboratory (center) based simulation' prior to participation in the In-Situ mock codes (Patterson, Geis, Falcone, et al., 2013). In one paper there was a retrospective review of both real life scenarios and simulated scenarios taking place in a simulation center or In-Situ (O'Leary et al., 2014). This suggested that as a learning experience for individuals they are comparable.

Characteristics of simulation scenario

The content of the simulation scenarios was developed with reference to clinical or safety experts, local or general experience as discussed above (Theme 1 8.7.1). The exact clinical scenarios used in each study could not be compared as the detailed information was not always published but there was an impression that clinical content was similar.

The majority of scenarios were aimed at paediatric intensive care or emergency staff (Bishop-Kurylo & Masiello, 1995) (P. H. Weinstock et al., 2005) (Toback et al., 2006) (Hunt et al., 2007) (Falcone et al., 2008) (Mikrogianakis et al., 2008) (Nishisaki et al., 2010) (Andreatta et al., 2011; Geis et al., 2011) (Nishisaki et al., 2012; Nwokorie et al., 2012; Stocker et al., 2012) (Cheng et al., 2013; Patterson, Geis, LeMaster, et al., 2013) (Theilen et al., 2013; Wheeler et al., 2013) (Auerbach et al., 2014; Katznelson et al., 2014) (Kurosawa et al., 2014) (O'Leary et al., 2014) (Kotsakis et al., 2015) (Couto et al., 2015). The In-Situ scenarios were usually held within the clinical environment but there was also reference to them being held in clinics or public spaces such as the cafe (Bishop-Kurylo & Masiello, 1995; Wheeler et al., 2013).

The timing of the clinical scenarios was predominantly in the daytime but two studies referred to mock codes occurring on night shifts (Patterson, Geis, Falcone, et al., 2013; Wheeler et al., 2013). A challenge of running In-Situ simulation scenarios is the clinical workload and ensuring attendance and the study from Scotland referred to the importance of protected time for attendance even when the simulation scenarios were In-Situ (Theilen et al., 2013).
One study made reference to simulation sessions being overscheduled in view of the need to cancel on occasion (Wheeler et al., 2013) and another talked of having clear criteria for cancellation (Auerbach et al., 2014).

The length of a simulation scenario varied from 10 – 15 minutes (Toback et al., 2006) (Couto et al., 2015; Kotsakis et al., 2015; Patterson, Geis, Falcone, et al., 2013; Wheeler et al., 2013) through 15-20 (Falcone et al., 2008; Mikrogianakis et al., 2008) (Auerbach et al., 2014; Couto et al., 2015; Nwokorie et al., 2012; Svavarsdottir & Brattebo, 2013) to a maximum of 45 minutes (Volk et al., 2011). The use of video recordings for debriefing or further analysis of the simulation scenarios was described in some studies (Falcone et al., 2008) (Allan et al., 2010; Messmer, 2008; Mikrogianakis et al., 2008) (Nishisaki et al., 2010) (Andreatta et al., 2011; Geis et al., 2011) (Nwokorie et al., 2012) (Cheng et al., 2013) (J. L. Kennedy et al., 2013; Patterson, Geis, LeMaster, et al., 2013) (Patterson, Geis, Falcone, et al., 2013; Wheeler et al., 2013) (Couto et al., 2015) and not in others (Bishop-Kurylo & Masiello, 1995) (P. H. Weinstock et al., 2005) (Hunt et al., 2007; Toback et al., 2006) (Hunt et al., 2008) (Volk et al., 2011) (Nishisaki et al., 2012) (Nwokorie et al., 2012) (Figueroa et al., 2013; Stocker et al., 2012) (Auerbach et al., 2014; Theilen et al., 2013) (Katznelson et al., 2014; Kotsakis et al., 2015; Kurosawa et al., 2014) (Zimmermann et al., 2015).

The physical realism of a scenario is primarily dependent on factors such as the environment, equipment and clinical fidelity of the simulated scenario and this is likely to have been enhanced with In-Situ sessions when practitioners were working in their normal environment. The details of the set up were not always available in the published article and both low / medium (Toback et al., 2006) (Theilen et al., 2013) and high fidelity

(Falcone et al., 2008; Hunt et al., 2008; P. H. Weinstock et al., 2005) (Allan et al., 2010) (Allan et al., 2010; J. L. Kennedy et al., 2013) (Andreatta et al., 2011; Volk et al., 2011) (Stocker et al., 2012) (Auerbach et al., 2014; Figueroa et al., 2013) (Katznelson et al., 2014) manikins were used. One study compared the use of low and high fidelity mannikins within the same simulated scenario and did not demonstrate any independent effect of manikin realism on team leader performance (using the BAT tool) or clinical team performance (using the CPT tool) (Cheng et al., 2013). Actors and faculty were used in some studies to play the part of a parent or auxiliary member of staff (Hunt et al., 2007; J. L. Kennedy et al., 2013; Toback et al., 2006). The use of a 'mobile' resuscitation cart or trolley that exactly replicates the resuscitation cart or trolley in use on a ward was described (P. H. Weinstock et al., 2009; Wheeler et al., 2013) to minimize potential clinical impact on availability of critical equipment and medication.

Debriefing

Debriefing was offered after the majority of simulation scenarios but the details of the method employed were not always given. The commonest debriefing technique referred to was the 'debriefing with good judgment' or 'advocacy inquiry model' of the Center for Medical Simulation in Boston (Rudolph, Simon, Rivard, Dufresne, & Raemer, 2007). The use of a standardised script for debriefing by less experienced instructors using this model was shown to improve performance during subsequent simulated cardiopulmonary arrests (Cheng et al., 2013). The amount of time devoted to debriefing was usually similar or longer than the amount of time taken for the scenario and ranged from 10 minutes (Patterson, Geis, Falcone, et al., 2013; Wheeler et al., 2013) to 30 minutes (Auerbach et al., 2014; Nwokorie et al., 2012; Svavarsdottir & Brattebo, 2013). It was also acknowledged that it was sometimes challenging to debrief all staff following an In-Situ simulation scenario because of the demands of returning to work (Wheeler et al., 2013) and another concern highlighted was that the failure to adequately debrief had the potential to improve confidence without a corresponding increase in skill (Hunt et al., 2007).

8.7.3 Theme 3: Teamwork: Defining and Evaluating

The concept of teamwork was discussed in Chapter 2. This theme was developed to encompass the evidence of whether there was a clear understanding of the concept of teamwork and what teamwork evaluation methods were used in the studies where there was explicit evaluation. Although teamwork was not clearly defined in the majority of studies, the use of the term crisis resource management or the assessment using specific validated tools provides a pragmatic definition by association. Teamwork can be considered as a non-technical skill that is required in the coordinated and effective execution of technical skills. A positive attitude towards the importance of teamwork as well as both individual comfort and confidence (or self efficacy) are also important factors in the performance of skills. This section will begin with a discussion of these latter areas before reviewing technical and non-technical skills and the tools used to measure teamwork, communication and collaboration.

Attitude, Comfort and confidence

Simulation education does appear to have a positive effect on attitude to teamwork when assessed using the safety attitudes questionnaire (SAQ) (Patterson, Geis, LeMaster, et al., 2013).

Self evaluation after a number of studies showed improvement in comfort and/or confidence (Bishop-Kurylo & Masiello, 1995; Toback et al., 2006) (Allan et al., 2010; Mikrogianakis et al., 2008) (Andreatta et al., 2011) (Figueroa et al., 2013; Stocker et al., 2012) (Katznelson et al., 2014; Kotsakis et al., 2015) which included comfort with performing procedural skills (Katznelson et al., 2014; Mikrogianakis et al., 2008) and better prepared to lead or participate in a code (Figueroa et al., 2013). In a study where the Paediatric Advanced Life Support Training was delivered in two different ways both groups showed improvement in confidence and satisfaction with their performance (Kurosawa et al., 2014).

Technical Skills

The importance of technical skills, as well as knowledge in the provision of high quality resuscitation is clear, and confirmation that resuscitation is not always optimally performed has already been referred to; procedures such as bag mask ventilation and cardiopulmonary resuscitation being performed incorrectly (Geis et al., 2011; Hunt et al., 2008). The assessment of time towards completion of essential tasks also showed unacceptable delay with it taking 90 seconds for adequate bag mask ventilation to be instituted in one study (Hunt et al., 2008).

Several studies described the application of technical skills as tasks within the scenario and demonstrated that simulation training with debriefing improved knowledge and technical skills as well as the efficiency with which patient reviews or tasks were performed (Hunt et al., 2007) (Patterson, Geis, LeMaster, et al., 2013) (Theilen et al., 2013). In the reconstructed pediatric resuscitation course (PALS) there was significant improvement in the scores of the Clinical Performance Tool (CPT), designed to measure tasks, with those participants on the reconstructed course that incorporated regular simulation and debriefing sessions (Kurosawa et al., 2014). There was no significant difference in CPT score in a study comparing non-scripted and scripted debriefing although there was a trend towards improvement with scripted debriefing (Cheng et al., 2013). A trauma multidisciplinary team simulation evaluation tool was used in evaluating regular 2 hour In-Situ trauma simulations in a study from Cincinnati (Falcone et al., 2008). In this study a comparison was made between between team performance during the first 4 months and the last 4 months and this demonstrated significant improvement in the timeliness of interventions as well as the appropriateness of interventions (Falcone et al., 2008). A large multicenter study involving 18 Emergency Departments from North Carolina showed significant improvement in the team performance of resuscitation tasks as evaluated using a previously developed trauma assessment tool (Hunt et al., 2007). An improvement in technical skills was not always described however; a study from the Children's Hospital in Philadelphia demonstrated no improvement in intubation skills or reduction in tracheal intubation associated events following the implementation of 10 minute sessions of skills training (Nishisaki et al., 2010) immediately prior to a clinical shift when assessed using a purposefully developed instrument (Nishisaki et al., 2012). The authors postulate a number of possible reasons for this that included the possibility that those intubating may not have fully acquired the skill (see 10.3.2). In contrast intubation skills did show a significant improvement over time in a study of regular monthly ED In-Situ simulated scenarios (Auerbach et al., 2014).

Post intervention surveys used to evaluate the course and participant's perception most commonly demonstrated a self-assessed improvement in knowledge and skills and these are discussed in more detail under the theme 'Evaluating .

Non Technical Skills / Team Functioning

One of the main goals of this project was to describe the characteristics of a simulation innovation that showed evidence of improved team functioning with an emphasis on the non-technical skills including communication. The importance of non-technical skills and team functioning in the provision of optimal care was reinforced by the outcome of a number of studies; these included examples of sub optimal care attributed to role clarity, sharing the mental model, updating and step backs, communication failures and loss of situational awareness (O'Leary et al., 2014; Patterson, Geis, Falcone, et al., 2013; Wheeler et al., 2013). One study also showed that in over 30% of simulated scenarios there was failure to identify a leader and those identified as leaders were often distracted by performing specific tasks (Hunt et al., 2008).

The way in which teamwork was defined was not consistent and a variety of methods were used in its evaluation that included validated tools or checklists or expert opinion. The scoring was commonly done using retrospective video review but this was not standardised in that some studies used a single reviewer, others two reviewers and the reviewers may have been blinded or not blinded to whether the scenario they were scoring occurred before or after a debriefing. A study of In-Situ trauma simulations from Cincinnati used a standardized tool adapted from Holcomb (Holcomb et al., 2002) and the improvement in timeliness and quality of patient care over time during the simulations was attributed to improvements in team functioning as a result of CRM education as well as the simulation experience (Falcone et al., 2008). An improvement in teamwork behavior was also demonstrated in a study from a pediatric emergency department using a similar, if not identical tool, where simulation was held regularly on a monthly basis In-Situ (Auerbach et al., 2014). There was a statistically significant improvement in overall performance and teamwork over time. A total team competency tool (Clinical Emergency Preparedness Team Evaluation (CEPTE)) was used to evaluate allergy clinic staff during 4 simulated scenarios and showed improvement in total scores following each scenario on a 1 day workshop (J. L. Kennedy et al., 2013). There was also improvement in the specific areas of leadership / role clarity, communication skills, teamwork/ support, situational awareness, scenario specific skills although these did not always reach statistical significance. This improvement was sustained during an In-Situ simulated scenario 10-12 months later (J. L. Kennedy et al., 2013).

In the reconstructed Paediatric Resuscitation Course, the Behavioural Assessment Tool (BAT) demonstrated an improvement in teamworking skills in the participants doing the standard course as well as those doing the reconstructed course but there was no significant difference between the two groups (Kurosawa et al., 2014). In the study comparing non scripted debriefing and scripted debriefing there was also a significant improvement in the BAT score for team leaders receiving scripted debriefing (Cheng et al., 2013). Self assessment of non technical skills also improved significantly with the establishment of the SPRinT program (Stocker et al., 2012).

In three papers no statistical improvement in team functioning was demonstrated (Mikrogianakis et al., 2008). (Patterson, Geis, Falcone, et al., 2013; Patterson, Geis, LeMaster, et al., 2013). Three different tools were used within these studies, a standardized tool adapted from Holcomb (Holcomb et al., 2002), ANTS and the modified Behavioural Markers for Neonatal Resuscitation Scale. The educational intervention in one of these cases was a single session of 12 hours (decreasing to 4 hours) (Patterson, Geis, LeMaster, et al., 2013) and monthly or weekly In-Situ training was the intervention in the other cases (Mikrogianakis et al., 2008) (Patterson, Geis, Falcone, et al., 2013).

In a simulation study used to assess the safety of new healthcare teams facilities, there were some interesting results regarding teamwork which was assessed using the Mayo High Performance Team Scale (MHPTS) (Geis et al., 2011): The teamwork scores were significantly higher in the simulation centre scenarios than within the In-Situ simulation. Increases in teamwork scores were demonstrated when a second simulation scenario was observed following initial debriefing in both locations although this improvement did not reach statistical significance (Geis et al., 2011). In contrast a comparison of teamwork between real life scenarios and those that were simulated, occurring In-Situ or in a simulation centre, was made using the TEAM tool and showed similar scores regardless of environment and whether the resuscitation was simulated or real (Couto et al., 2015). In this study most videos were scored by 1 reviewer but 21 videos were scored by a second reviewer and the reviewers were found to be consistent on 96% of the items, evidence of inter rater reliability.

In other studies there were specific aspects of teamwork that showed particular improvement that included those of communication (see below) and shared leadership (O'Leary et al., 2014) with the definition of a nursing leadership role in response to verbalization of a nursing medical hierarchy (Patterson, Geis, Falcone, et al., 2013). In this latter study several members of the team acknowledged observing practice that was not in accordance with protocol but feeling unable to communicate their concern.

Collaboration and Communication

The areas of collaboration and communication were focused on in a couple of studies; in a study looking specifically at nurse physician collaboration there was a significant improvement in collaboration following the simulation of three mock codes within stable teams. The instrument used to assess collaboration in this study was the Schmalenberg Nurse-Physician Scale (KSNPS) (Messmer, 2008) and the authors describe the participants as moving from silo (discipline) to collaboration (interdisciplinary). Interestingly these results did not correlate with the perception of collaboration by participants which was assessed using two instruments; the Collaboration and Satisfaction with patient Care Decisions (CSPCD) and Clinical Practice Group Cohesion).

The study from Sydney highlighted communication as a significant factor responsible for suboptimal care (O'Leary et al., 2014) and communication was identified as responsible for some of the errors observed during study from Baltimore (Hunt et al., 2008). In another study where participants were placed in a situation where they were expected to communicate concerns, it was noted that many of them did not (Patterson, Geis, Falcone, et al., 2013). An improvement in participants' perceived ability to 'speak up' was demonstrated following simulation within a cardiac intensive care unit (Allan et al., 2010). An initiative that studied the area of communication specifically demonstrated an improvement in the use of techniques such as clarity and specificity of language as well as the use of closed loop communication (Nwokorie et al., 2012). In others communication was assessed as part of the assessment of teamwork using one of a number of tools or as part of the self- assessment and showed evidence of improvement (Couto et al., 2015; J. L. Kennedy et al., 2013). The area of communication that showed most improvement following simulation and debriefing were speaking in a loud clear voice, using closed loop communication, use of accurate and specific language and supporting colleagues. (Figueroa et al., 2013; Nwokorie et al., 2012),

8.7.4 Theme 4: Evaluation: Intervention and Self Assessment

This thematic construct refers to the strategies of evaluation incorporating those aimed at the innovation itself as well as the individual and teams participating.

Kirkpatrick level 1

This refers to the reaction of participants to the simulation sessions and is effectively an evaluation of whether participants find the training engaging and relevant. In the majority of studies where this was assessed there was a positive response to simulation (Allan et al., 2010; Messmer, 2008; Mikrogianakis et al., 2008; Patterson, Geis, LeMaster, et al., 2013; Toback et al., 2006; Volk et al., 2011) (Wheeler et al., 2013) (Auerbach et al., 2014; Couto et al., 2015; Katznelson et al., 2014) (Kotsakis et al., 2015). A poor survey response was demonstrated in one study designed to evaluate new healthcare facilities with some negative comments (Geis et al., 2011). It is not clear why this was the case as it is not discussed.

Kirkpatrick level 2

Level 2 is often subdivided into:

a) An evaluation of attitude (including confidence) or
b) Knowledge (which for the purposes of this review can also include skills)

The complicated relationship between confidence or self-efficacy and skill acquisition or competence has already been discussed (8.7.3) and in a paper from the Children's Hospital of Philadelphia there was little correlation between the participants' self efficacy in performing a skill, such as ventilating with a bag and mask, and the objective assessment of that skill (Kurosawa et al., 2014). An improvement in confidence or comfort following simulation was demonstrated in several studies (Bishop-Kurylo & Masiello, 1995; Toback et al., 2006) (Allan et al., 2010; Mikrogianakis et al., 2008) (Andreatta et al., 2011) (Figueroa et al., 2013; Kurosawa et al., 2014; Stocker et al., 2012) (Katznelson et al., 2014; Kotsakis et al., 2015). The use of clinical simulation to enable practice of the rare event of acute paediatric deterioration within rural practices resulted in improved confidence, comfort or satisfaction in dealing with those situations (Toback et al., 2006).

The evaluation of knowledge and skills occurred in two distinct ways:

- Administered questions and / or observation of skills
- Self assessment questionnaire

In the study of Paediatric Allergy Clinics retention of knowledge and skills was demonstrated at a follow up In-Situ simulation held 10 – 12 months after the workshop training (J. L. Kennedy et al., 2013). An improvement in knowledge, assessed using multiple choice questions, was also shown with scripted debriefing following simulated paediatric resuscitation (Cheng et al., 2013).

The SPRinT program's self evaluative questionnaire following the simulation intervention contains categories that included technical and non technical skills which showed a significant improvement as the program became established (Stocker et al., 2012). In four studies there was the administration of precourse questionnaires that were compared to post test questionnaires (Mikrogianakis et al., 2008) (Figueroa et al., 2013) (Katznelson et al., 2014; Patterson, Geis, LeMaster, et al., 2013). They were designed using statements that the candidate could agree or disagree with using a likert scale. These statements varied between studies but included those aimed at participant's perception of paediatric resuscitation knowledge and skills, their confidence as well as evaluation of themselves and the team (Mikrogianakis et al., 2008) (Figueroa et al., 2013) (Patterson, Geis, LeMaster, et al., 2013) (Katznelson et al., 2014). The results from the Project CAPE study, which involved staff working at 'Critical Access', or 'Rural' Hospitals, reported a high level of agreement with the statement 'participating in this scenario improved my clinical skills' (Katznelson et al., 2014). A similar result was seen in the study from a cardiac intensive care unit where participants continued to report a significant improvement in perceived clinical skills 3 months after the simulation intervention (Figueroa et al., 2013). Significant improvement was also demonstrated 10 months after a standardized simulation session for paediatric emergency department staff (Patterson, Geis, LeMaster, et al., 2013). In the study by Mikrogianakis there was a fall in knowledge relating to location of equipment within the emergency department but there was an improvement in the self evaluation of knowledge regarding priorities in resuscitation (Mikrogianakis et al., 2008).

Kirkpatrick level 3

A change in behavior needs to be demonstrated in order to fulfill criteria for Kirkpatrick level 3. This can be considered as being fulfilled in those studies that demonstrated an improvement in teamwork or communication during simulated scenarios, as have been discussed above (Falcone et al., 2008) (Auerbach et al., 2014; Couto et al., 2015; J. L. Kennedy et al., 2013; Kurosawa et al., 2014; Nwokorie et al., 2012; O'Leary et al., 2014; Stocker et al., 2012). An improvement in leadership behavior analysed using the Team Leader Behavioural Tool (BAT) was also demonstrated with the scripted debriefing methodology (Cheng et al., 2013).

There was other evidence of a change in either individual or team behavior with reference to the performance of resuscitation 'tasks' or technical skills. In the study of 18 North Carolina Emergency Departments there was a significant improvement in the number of ED teams that passed an overall assessment (based on a passing score for specific tasks) following the simulation intervention when compared to the initial assessment as well as in the 3 specific areas of examination of the head, neck and chest (Hunt et al., 2007). This data was also analysed with reference to the performance of each specific task and showed that in 11 of the 44 tasks there was a significant increase in the proportion of EDs that passed.

Kirkpatrick level 4

This refers to the highest level of evaluative effect, which in this context is specifically a change in patient outcome. This was explicitly demonstrated in three studies (Andreatta et al., 2011; Theilen et al., 2013) (Patterson, Geis, LeMaster, et al., 2013) although the study from Cincinnati (Patterson, Geis, LeMaster, et al., 2013) is cautious in attributing the decrease in patient safety events to the innovation. In addition the study from Couto demonstrated correlation between the teamwork scores during simulation scenarios and clinical scenarios which can be considered as a change within an organization even though the aim of their study was not to collect data related to patient outcome (Couto et al., 2015). Further evidence for change with an organization was referred to as being implemented as a direct result of findings from the simulation studies (Patterson, Geis, Falcone, et al., 2013) (Auerbach et al., 2014)which contributes to sustainability (below).

8.7.5 Theme 5: Service development – embedding resilience.

The final theme is closely related to the first but refers specifically to the concept of sustainability. The study that hinted at Level 4 responses is ongoing as part of the Cincinnati Children's Hospital Initiative (Patterson, Geis, LeMaster, et al., 2013). The two studies that demonstrated Kirkpatrick level 4 evaluation have been developed and continue to provide simulated experience (Andreatta et al., 2011; Theilen et al., 2013) .In the first study from the University of Michigan the authors refer to the mock code program being routinely integrated into their residency program (Andreatta et al., 2011). The second study, from Scotland, described the implementation of a new multidisciplinary medical emergency team as well as the establishment of weekly simulation training as a response to the identification of quality of care concerns (Theilen et al., 2013). The authors describe further improvement in care over the following year in the conclusion to their paper. The SIMPeds (P. H. Weinstock et al., 2005) (Allan et al., 2010) (Volk et al., 2011) and SPRinT (Stocker et al., 2012) programs are also sustainable programs that have developed their own supportive infrastructure.

The majority of the published studies were described as pilots or descriptive studies and the implication was often that these would continue in some way but those that explicitly referred to the continuation or development of the course are referred to here: Some of the studies that prioritized the identification of latent safety threats described ways in which these threats were further evaluated and processes adapted to decrease future risk. This included developing guidelines to standardize or clarify roles within the resuscitation team (such as creating a nurse lead and clarifying roles of first responders), updating the resuscitation flow chart (to include concept of shared mental model) and processes regarding communication (Hunt et al., 2008) (Patterson, Geis, Falcone, et al., 2013) (Patterson, Geis, LeMaster, et al., 2013; Wheeler et al., 2013). The study from Baltimore described changing the code team to a rapid response team to encourage referral and describe developments in the resuscitation curriculum. The other three studies were from Cincinnati Children's Hospital (Patterson, Geis, Falcone, et al., 2013) (Patterson, Geis, LeMaster, et al., 2013; Wheeler et al., 2013) where a multifaceted quality improvement program has been designed to improve the early recognition and management of the critically deteriorating child. The simulation intervention has continued and the confidence of leadership in its effect was referred to. Two other studies from Cincinnati Children's Hospital included the pediatric trauma team training (Falcone et al., 2008) and the study that compared teamwork scores from clinical scenarios to simulated scenarios within a simulation centre or In-Situ (Couto et al., 2015). Another In-Situ trauma simulation program has been established at Yale-New Haven Children's Hospital (Auerbach et al., 2014) and the authors refer to the fact that the identification of latent safety threats has created support from leaders and course feedback has been used to update and improve the program. The Mock Trauma Code Program established in Toronto also continues, (Mikrogianakis et al., 2008)

An initiative aimed at Primary Care (Toback et al., 2006) and the CAPE Project (Katznelson et al., 2014) aimed at Critical Access Hospitals facilitated the continuation of the educational initiative and quality improvement by providing simulation equipment (Katznelson et al., 2014; Toback et al., 2006) and resuscitation resources (Toback et al., 2006).

Although the intention was for those simulation initiatives described above to continue, the sustainability of any program is affected by a variety of factors. The study authored by Wheeler makes reference to the need to cancel In-Situ simulations when clinical workload is high (Wheeler et al., 2013). This and other factors will be elaborated on in the discussion.

8.8 Summary

This narrative review of the literature revealed some interesting information both in the methodology of the research as well as in the results. This has been summarized as a thematic analysis and these themes will be further explored in Chapter 9.

8.9 Visits to International Centres

The two simulation programs that I visited were:

- SimPeds at Boston Children's Hospital, Boston, USA
- SPRinT at The Royal Brompton Hospital, London, UK

This chapter begins with a background description of these simulation programs before discussing aspects of their programs that are of direct relevance to the establishment of a Paediatric Simulation Program, particularly regarding interprofessional teamwork or CRM training. The information presented was obtained from a combination of publicly accessible material from their individual websites (as well as the IPSS website) and the conversations and observations made during my visits in 2015.

8.10 SIMPeds Program

8.10.1 Background

Boston Children's Hospital established their SIMPeds Program in 2001 and I completed their Instructor Course in 2008 as well as a further Instructor day provided by SIMPeds faculty and hosted in Auckland, New Zealand in 2012. This meant that I was familiar with their program and had established communication with Professor Peter Weinstock, their program director. The SIMpeds program has published a number of influential papers on the use of simulation in paediatrics (Allan et al., 2010; Flores & Weinstock, 1996; Volk et al., 2011; P. Weinstock, 2012; P. H. Weinstock et al., 2009; P. H. Weinstock et al., 2005), two of which were referenced as part of the literature review (P. H. Weinstock et al., 2009) (Volk et al., 2011). A full list of their publications is in the appendix (appendix x).

8.10.2 Timetable of Visit

Unfortunately due to excessive snow in Boston the flights into Boston were cancelled and I was unable to arrive until the evening of Tuesday 10th February 2015. This reduced the original visit from 1 week to 3 days. The aim of my visit was to have the opportunity to observe aspects of the SIMPeds program and to meet and discuss the program with members of the SIMPeds staff and Clinical Educators and the timetable that was prepared for me is shown below:

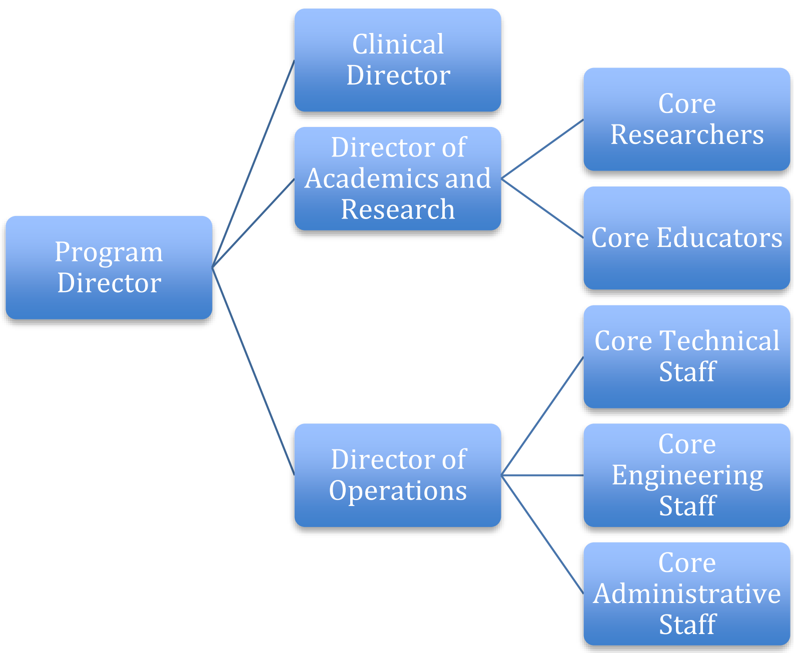
Wednesday 11th February	
10.00	Director SIMPeds; PICU (Medical)
11.00	Supervisor SIMPeds Technical Staff
12.00	Lead Faculty SIMPeds; Newborn Medicine (Medical)
1PM	Lead Faculty SIMPeds Cardiac ICU; Nursing Educator
2.00	Manager SIMPeds
	Research SIMPeds: Organisational Psychologist
Thursday 12th February	
08.00	Observe NICU Graduate CRM course
12.00	Observe Debrief NICU Facilitators
2.00	Lead Faculty SIMPeds; Emergency Medicine
3.00	Director of Operations SIMPeds
4.00	Simulation Technician SIMPeds
Friday 13th February	
07.15	Observe PICU In-Situ Simulation of Mock Code

These interviews provided me with the opportunity to have open discussion with key staff. This discussion was unstructured but was informed by the trigger areas identified in Chapter 6 and field notes were taken.

8.10.3 Leadership and Governance

The embedding and maintenance of a relatively small simulation program may require no more than personnel with enthusiasm and these skills. However, in a similar way to the successful management of healthcare operations or businesses, a sustainable simulation program needs a leadership and governance structure. In 2002 there were 3 personnel who contributed to the SIMPeds program, which included Peter Weinstock, operational support and a technician. The number of SIMPeds staff has increased significantly since my first visit in 2008 and is very likely to have been a contributory factor in Boston Children's Hospital being ranked as the top Children's Hospital in the USA. Prior to my visit a new leadership structure had been formalized as shown in Figure 10 below:

Figure 9: SIMPeds Leadership Structure



Regular leadership meetings had been instituted and there were monthly staff meetings. Policies and procedures were in the process of being reviewed and updated and parallels were drawn by one of the leadership team members to strategies similar to those used in a 'start up' company.

8.10.4 Planning and development of simulation scenarios

The SIMPeds program has developed resources to support and facilitate departments in the writing of educational objectives and the development of specific clinical scenarios. Departments that have written a scenario and are running it as part of the SIMPed program will submit a 1page summary for sign off to the Director of the SIMPed program. This encourages departmental responsibility to conduct their own needs analysis and design objectives that meet this need, while the SIMPeds sign off ensures that minimum standards are met. A central coordination of simulation scenarios also ensures that departments with similar learning objectives and / or scenarios can be encouraged to share ideas and / or resources.

8.10.5 Maintenance of equipment including manikins

At the time that I did the Instructor Course in 2008 there was 1 technician. This number has now increased to 9 as the number of courses has continued to increase. The operational strategy of the SIMPeds program places the technicians as the main conduit or link between SIMPed permanent staff and the departments participating in the program and using this model they are one of the keys to the sustainability of the program.

8.10.6 Expertise in the delivery and debriefing of scenarios

Expertise in the delivery and debriefing of scenarios is also key to a sustainable program and there needs to be processes to orientate and develop the specific skills associated with simulation and to ensure continuous professional development of staff. In the SIMPeds program the term 'superfacilitator' is used to describe an individual that has completed the 3 day instructor training. They may come from a variety of professions and are able to lead debriefing in departments other than their own. The term 'facilitator' is used to describe an individual that has completed a half day session in instructor training who works to facilitate sessions within their own department.

8.10.7 Environment and equipment

In 2015 at the time of my visit, the SIMpeds program was rapidly expanding and there were plans to significantly increase the physical environmental resources. The directors and managers of the program had exclusive office and administrative space and there was storage space within the basement of the hospital. There were also 3 rooms allocated solely to the delivery of the SIMPeds program that consisted of;

- The PICU simulation room.
    - This had an associated audiovisual control room
    - This had camera views of the simulation room only
- Unit adaptable room within hospital (see photo taken)
- Surgical training room with laparoscopic and virtual reality (next to theatres)
    - 24 / 7 access using ID card entry
    - All visitors recorded on digital video

Figure 10 : PICU Simulation Room

B line medical were the audiovisual supplier for the SIMPeds program at the time of my visit. This is a web based system which allows access to the video recording from the internet without the need for specific hardware. Laerdel has developed a system with some similarities that also acts as a program management system and the SIMPeds Program was assessing the functional capability of both systems as they planned their further development.

The SIMPeds group has published regarding the cost effective use of Mobile Carts for In-Situ simulation (P. H. Weinstock et al., 2009). At the time of my visit these carts were being redesigned but the concept is one of a fully mobile simulation unit that facilitates the rapid set up of a simulation scenario. This can be within the clinical area of a hospital or a non clinical area such as a corridor or café. As a consequence of the In-Situ simulation interventions the SIMPed program has developed 'simulated emergency' or 'simulated code' trolleys that are identical to the ward emergency or code trolleys. This strategy is now used widely and is regarded as the safest strategy when delivering In-Situ simulation for a number of reasons;

- It ensures that no 'simulated medication' finds its way into the hospital system as the medication is viable.
- The medication is fully costed into the simulation intervention and not taken out of ward budgets
- The ward emergency or code trolley remains fully stocked should a clinical emergency occur within a short time period of the In-Situ mock code.

Mannequins are a significant initial cost outlay and in 2015 the SIMPeds Program had the following mannequins available:

- Newborn
  - 2 X Laerdal SimNewB
  - 2 X Guamard Newborn Hal
- Infant
  - 8 X Laerdal SimBaby
- Child
  - 3 X Laerdal SimJunior
  - 1 X Guamard 1year old Hal
- Adult

    - 3 X Laerdal SimMan
    - 1 X Laerdal SimMan3G

The SIMPeds program have implemented strategies to minimize the cost of replacement and maintenance by ensuring that the mannequins remain functional for as long as reasonably possible. This includes:

- Hospital wide centralized resource program
- All mannequins remain under warranty
- Employment of skilled technicians
- Mannequins are lent only to departments with SIMPed technician support.

8.10.8 SIMTrain™

SIMTrain™ is the term used to describe the area of the SIMPeds program that concentrates on clinical simulation scenarios. SIMTrain™ Courses are delivered by 'superfacilitators' with the help of departmental facilitators. As the SIMPed Program has expanded, the number of simulation courses being run has also increased, many of which include non-technical skills such as teamwork or CRM. At the time of my visit there were 58 different types of courses run within the clinical departments of Boston Children's Hospital as well as at other hospitals.

8.10.9 A Structured Curriculum

The SIMPeds program has developed a curriculum of clinical simulation experiences that include interprofessional simulation designed to enhance the skills of crisis resource management and teamworking. The SIMPeds Program defined critical event management as requiring

- Role Clarity
    - The term used for the Team Member (s) leading and coordinating the team was event manager. They often designate a Medical and Nursing event manager

- Communication
    - Emphasis on ISBAR and closed loop communication
- Personnel Support
- Resources
- Global Assessment

As the area of simulation has expanded the SIMPeds program has developed the 5 zone approach to ensure that CRM and Teamwork training are seen as aspects within a wider curriculum. The zones are below;

- Zone 0: Pure Technical
- Zone 1: Clinical Competency
- Zone 2: Contextualised Skills
- Zone 3: Team Training (CRM)
- Zone 4: Live Event Debriefing

8.10.10 Delivering and Supporting Simulation Scenario Training

The SIMPeds Program had expanded to be able to deliver and/or facilitate 3-4 simulations per weekday and occasionally this may reach 6/7. This is a total that exceeds 100 courses per year. There are several key components that define the operation of SIMPeds (in addition to those described above). These include;

- The use of the "Basic Assumption' from the CMS
    - "We believe that everyone participating in activities in the Simulator Program is intelligent, well trained, cares about doing their best and wants to improve"
- The concept of 'super' facilitators and facilitators of simulation training.
    - The training and experience of the 'super' facilitators in simulation is such that they have the skills to facilitate training in departments other than their own.
- Flexible approach to the timing of training

    - Scenarios can be run from 630 am until 8 pm. Courses are occasionally run at weekends and workshops next to conferences
    - This approach has increased participation from some departments that have predictable high clinical load at certain times that would prevent engagement with simulation at these times.
- The SIMPed technician coordinates with the department running a scenario and prepares the site and manikin and runs the scenario

8.11 Non Participant Direct Observation

I was able to observe a neonatal CRM course and an In-Situ PICU CRM Simulation and these are briefly described below:

8.12 Neonatal Simulation

8.12.1 Relevant Clinical Background

At the time of my visit there were 7 neonatal units within the Boston Neonatal Network and 2 of these are in the adjacent hospitals of Boston Children's Hospital and Brigham Women's Hospital. The birthing / delivery suite is located at the Brigham Women's Hospital and their neonatal unit admits 1400 babies per year. In comparison Boston Children's Hospital has 600 admissions per year. This compares to 1000 admissions in 2015 at the Neonatal Unit in Christchurch New Zealand.

8.12.2 Simulation Courses

As the SIMPeds program has expanded the type and frequency of simulation courses offered at each neonatal unit within the Boston Neonatal Network has also expanded. These include:

- The provision of 6 sessions over a 16 week orientation for new staff
- Simulation scenario training on specific clinical issues

    - Regular needs assessment occurs every 18 months to ensure that the clinical simulation scenarios are based on local experiences.
- Crisis Resource Management Training
    - 4.5 hour 'primer' course to introduce the principles of CRM
    - 4 hour 'graduate' monthly CRM training
- Parent skill based simulation training

The aim has been to embed simulation within the departmental training curriculum. The implementation within the different neonatal units and / or hospitals has been variable. In some places the training is regarded as mandatory and there is an expectation that staff participate in training at least every 2 years.

I observed a graduate CRM course on Thursday 12th February 2015

8.12.3 Graduate CRM Course

The graduate CRM course is 4 hours in length and the assumption is that those on the graduate course are familiar with the language and principles of CRM because of their attendance at a Primer course. The principles of CRM that are focused on specifically are:

- Leadership / Role clarity
- Effective communication
- Equipment
- Personnel resources / Chain of command
- Global perspective

The 'graduate' course uses a standardized template that incorporates a variety of teaching methods:

- Introductions
- Revision of CRM Principles
- Clinical Simulation Part 1
    - Scenario and debrief

- Consolidation of relevant clinical information (eg breaking bad news)
- Clinical Simulation Part 2
    - Scenario continued and debrief
- Clinical Simulation Part 3
    - Scenario continued and debrief
- Evaluation and closure

The Neonatal Faculty of SIMPeds has a repository of clinical scenarios for the CRM training.

Observation of Simulation

The detailed timetable and scenario details for this CRM graduate course on Thursday 12th February are provided in Appendix vii and viii.

Location

The simulation was held within the SIMPeds simulation training room, which was set up in a similar way to the neonatal unit.

Faculty

The Neonatal CRM course had an interprofessional faculty of 4 individuals from both nursing and medicine and there were 2 observers, including myself.

Participants

The participants were from nursing and medicine. They were asked if they could remember back to the primer course that they attended. Some of them could not and my impressions during the simulation and discussions that I observed were that the language of CRM was familiar but not yet totally automatic.

Simulation Scenario

The specific scenario that I observed was of a preterm baby who was becoming increasingly unwell from necrotizing enterocolits (a recognized complication of prematurity where the intestine breaks down). She eventually died. Actors played the part of the parents in the second and third part of the simulated scenario.

Debriefing

The advocacy inquiry method of debriefing (defined in Chapter 4) was utilised and the actors were also called in to share their perspective. I wondered but did not enquire about the extent to which the actors were briefed. Their contribution and perspective was valuable although I wondered if their expectations of healthcare were a little idealistic – 'that we can train to the point where no harm happened to any child'. This opinion may reflect my own biases in this area as my continued involvement with human factors and teaching patient safety leads me to believe that risk will never be eradicated

The emphasis in this session was about maintaining an open dialogue with parents. There were suggestions to enhance communication such as specific movements and phrases but it was also reinforced that the specific nature of the diagnosis and the complexity of each individual family member's personalities and emotions meant that there was not a checklist. The lead faculty member emphasised the importance of hope and made the valid point that the focus of hope may change but that there is always hope.

8.13 PICU Simulation

8.13.1 Relevant Clinical Background

As previously mentioned, Boston Children's Hospital has two Pediatric Intensive Care Units: The 30 bed Medical Surgical Intensive Care Unit and a 12 bed Medicine Intensive Care Unit. There is access to theatres, cardiac catheterization and extracorporeal membrane oxygenation.

8.13.2 Simulation Courses

Mock codes are less than 1 hour in length and the aim is that participating staff will have received previous CRM simulation training and that this will be reinforced by an unscheduled observed mock code and debriefing. The principles of CRM emphasised are those previously described.

I observed an In-Situ Mock Code on Friday 13th February 2015.

8.13.3 Observation of Mock Code

The PICU Faculty of SIMPeds have a repository of clinical scenarios for the CRM training. The faculty and technical staff are very familiar with these and participants were not given any written material.

Location

The PICU mock code that I observed was In-Situ on the Paediatric Intensive Care Unit.

Faculty

There were two faculty members, a clinician and technician, and myself as an observer. Peter Weinstock has a phenomenal amount of experience in the running of In-Situ simulation. As he was the only faculty member he took on the following educational roles:

- Scenario director
- Liaison with technical staff
- Observer of practice within the scenario
- Lead debriefer

Participants

There were 6 participants from the medical profession and at various stages in their training on a paediatric intensive care unit.

Clinical Scenario

The scenario used was an infant on PICU who had developed an arrhythmia and required defibrillation. The scenario progressed as planned and it was stopped at a point when there was a significant amount of activity and heightened emotions. This worked well and seemed a more valid approach than waiting for the patient to start to respond to interventions.

Debriefing

The technique of advocacy inquiry was used in the debriefing. The time given to debriefing was short by comparison with other experiences. The maximum time to debrief was 10-15 minutes. A particular focus of the debriefing was the fact that one of the team made it clear that the defibrillator being used was outside of his scope. The importance of simulation training with this type of defibrillator was reinforced.

8.14 Evaluation of SIMPed Courses

Direct evaluation of the effectiveness of simulation in team training is accumulating. Providing direct evidence in support of these educational interventions requires both new research and continuous audit. Boston Children's Hospital was recognized as Best Children's Hospital in the USA in 2015 and that may also represent indirect evidence of the success of SIMPeds along with other initiatives within the hospital. The leadership of SIMPeds also reinforced the idea of anecdotal feedback; this is when they receive verbal or written feedback where a successful outcome to a critical event is attributed by an individual or department to a simulation session in which they participated. These 'stories' are shared with the managers and leaders of the hospital.

Insurance companies fund healthcare in the USA and it is also of interest that CRICO (Controlled Risk Insurance Company) provides funding for some simulation courses in view of the important effect it has on patient care. This is a powerful message that indicates that an Insurance company likely has evidence that simulation training reduces risk to the insurer.

The Director of Research had recently been appointed prior to my visit and one of their roles was to develop a more systematic audit and research strategy to further provide evidence of the benefit of an embedded simulation program.

8.15 SPRinT Program

SPRinT is the abbreviation for Simulated interPRofessional Team Training Program. The Royal Brompton Hospital established their SPRinT program in the United Kingdom in 2008 and this program was developed from the Boston SIMPed Program. Lydia Lofton coordinates this program and presented at the International Paediatric Simulation Society conference in Vienna, Austria in 2014. I attended this conference and established communication with Lydia shortly after. The SPRinT program has published a number of papers on the use of simulation in paediatrics (i) and two of these were referenced in the literature review (Stocker et al., 2012) (Zimmermann et al., 2015).

At the time of my visit the SPRinT Program was running a SPRinT course on three out of four Mondays, which is 36 courses per year. These are predominantly aimed at Paediatric Intensive Care staff but a course is run every 6 weeks for the paediatric ward teams. In addition there are some outreach courses. The aim is that each doctor participates in a SPRinT course once every 6 months and each nurse once every 12 months.

As part of this program they run:

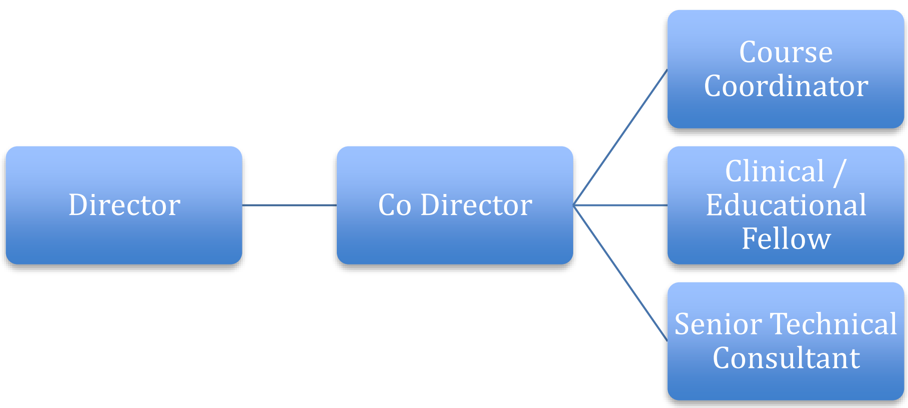
- Introductory Facilitators Course
- Advanced Facilitators Course
- SPRinT PICU Courses
- SPRinT Neonatal Cardiac Emergencies

8.15.1 Timetable of Visit

I spent an afternoon visiting The Royal Brompton that included talking to the SPRinT Coordinator Lydia Lofton and observing a multidisciplinary CRM course for staff on one of their wards.

8.15.2 Leadership and Governance

The SPRinT Director is a PICU Consultant who also has additional roles in educational leadership both in the United Kingdom and Internationally. A Consultant Anaesthetist assists her in Directing SPRinT. Lydia Lofton is a nurse educator who continues to work clinically and coordinates and leads SPRinT courses. There is Senior Technical Support and there has been the recent appointment of a clinical educational fellow.



8.15.3 Planning and Development

The scenarios are developed from clinical events that have occurred on the PICU or cardiorespiratory wards. These clinical events may be those that are rare and unfamiliar to most staff or may have been associated with recent adverse events.

8.15.4 Maintenance of equipment

There is a technician that supports the running of the SPRinT courses and maintenance is also performed under an extended Laeredal contract.

8.15.5 Expertise in the delivery of simulation and debriefing

The SPRinT program runs both an introductory and advanced instructor training course and has developed a resource of interprofessional faculty. Each SPRInT course is led by a combination of nurse / medical facilitators mainly from PICU but also from other ward areas when their ward is involved.

8.15.6 Environment and Equipment

In the past there was a room on PICU reserved for simulation but clinical workload mean that this can no longer be guaranteed. However, the simulations are usually held In-Situ and if this is not possible they are held in one of the sleep laboratory rooms, adjacent to the PICU, and a seminar room is used for debriefing. A new rebuild is planned.

At the time of my visit the mannikins available were:

- Laerdal SimBaby
- Gaumard Paediatric HAL
- Local Patented Cardiac Mannikins (co designed with cardiac surgeons)

8.16 Observed SPRinT Course

The timetable for this 2 hour SPRinT course on Monday 20th April are in Appendix ix. The SPRinT course follows a standard format

- Introductions and Icebreaker
- Human Factors and CRM
- Orientation to Simulation Environment
- Simulation
- Debriefing
- Summary and evaluation

Faculty

There were 3 faculty, 2 nursing and 1 medical, and I was observing.

Participants

There were 9 participants, 5 nursing (1 from PICU and 4 from the ward) and 4 medical (anaesthetics, cardiology, PICU).

Clinical Scenario

The Clinical Scenario was one of an infant with Tetralogy of Fallot (a congenital heart condition). The infant was having episodes of cyanosis known as ‘spells’ (where the blood basically bypasses the lungs so that the infant becomes deoxygenated.

Introduction and Discussion

The introduction was led by Lydia with the PICU Consultant supporting.

The icebreaker involved throwing a ball to each other and an analysis of emotions and behavior. This stimulated open discussion around leadership and speaking up and the sharing of experiences.

The principles of CRM were revised and discussed using a powerpoint presentation before beginning orientation to the simulation and the clinical scenario itself.

Orientation

There was orientation to the concept of a ‘safe’ educational environment, the simulation mannequins themselves and also the debriefing method that would be used.

Running Scenario

There was technical support and one of the faculty members controlled the vital signs of the mannequin as the scenario developed. The resuscitation trolley was a simulated trolley and the remaining equipment was as used in the workplace.

Scenario

I saw good communication initially and good leadership. It was noticeable that as the doctors arrived and things became more complicated there was less clear leadership, a pattern that I have seen both in simulation and in reality. Parents were not present. There was a clear request for senior help from one of the nurses and the scenario was stopped while patient still unwell.

Debrief

The advocacy Inquiry method was used to good effect. I did wonder whether some of the candidates showed signs of distress with this technique and an increase in tension. This is not infrequently seen when the Basic Assumption is not fully implemented into the work environment in which the simulation candidates practice, especially when faculty include senior members of the clinical team.

8.17 Evaluation of SPRinT courses

In a similar way to with SIMPeds there is not yet a systematic continuous audit or research program to evaluate the SPRinT courses. The two main evaluative methods are:

- Identification of latent threats and design of system improvements
    - These and other lessons learned are shared in the monthly paediatric Newsletter, quarterly SPRinT bulletins and in presentations to the Hospital Board for the Risk and Safety Forum.
- Staff perception
    - Staff that attend SPRinT courses complete an initial evaluation form (Kirkpatrick level 1) and some staff complete a further questionnaire following clinical resuscitations to investigate their perceptions of how the course impacted their performance (Kirkpatrick level 3).

9 Discussion

This chapter will explore the results of the thematic analysis of the literature review and also reference the visits to SIMPeds and SPRinT. The aim of this exploration is to begin to develop the beginning of an operational strategy for the implementation of an interprofessional program in teamwork within acute paediatrics.

9.1 Orientating to Resilience: A continuous safety audit

Healthcare is increasingly complex and the decisions made at both the individual and organisational level affect the lives of our patients, adding to the specific stresses of our roles. These factors have stimulated an increasing emphasis on the term resilience, both individual resilience for the healthcare workers, and organisational resilience. Organisational resilience was defined in Chapter 1 (1.3) but this definition is repeated here with the definition for individual resilience below:

Organisational Resilience

An organization that anticipates, prepares for, responds and adapts to incremental change and sudden disruptions in order to survive and prosper.

Individual Resilience

Resilience is the process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress.

The theme 'Orientating to Resilience: A continuous safety audit' describes elements of the educational intervention where there was either some type of needs analysis done in advance of the intervention (Zimmermann et al., 2015) or where a type of needs analysis or safety audit occurred as part of the simulation education intervention with the identification of latent errors for example; examples of sub optimal resuscitation and system or latent errors were demonstrated in some of the educational interventions described within the literature review (Hunt et al., 2008) (Geis et al., 2011) (Patterson, Geis, Falcone, et al., 2013) and also in both the SIMPeds and SPRinT programmes. There is an argument to say that this is no longer required in that there has been a great deal of work both in healthcare and other industries (especially the airline industry) to understand patterns of error and situations where that error is most likely to occur. It is also implicitly clear that clinical situations that are rarely encountered are those that need to be prepared for using simulation. Does each healthcare organization really have to collect their own data? There are some alternative arguments though; the first of these is the importance of hearing the patient and family viewpoint. A patient that has suffered because of inadequate processes and a failure to acknowledge mistakes often gains some relief by knowing that their suffering has contributed to, or provided the trigger for an improvement in systems. This open disclosure model of mistakes where patients are fully informed is widely promoted within healthcare internationally by leaders in healthcare and governance organisations and in New Zealand we have the Patient Code of Rights from the Health and Disability Commissioner (http://www.hdc.org.nz/the-act--code/the-code-of-rights/the-code-(full).

A second important consideration is that changing behavior and systems within large organisations requires staff engagement; they need to have a clear understanding of the benefits of the change as well as motivation to make that change. A local 'needs' (or 'wants') analysis helps to promote staff engagement.

There are still significant barriers within healthcare organisations to acknowledging the mistakes that have occurred to ourselves, to the patient and the team in a way that ensure healthcare develops a strong resilience and learning culture. The healthcare organization itself then has a responsibility to these staff to provide a physical and sociocultural environment (systems) that supports them in these changes. This is where an understanding of Human Factors is critical. The definition of Human Factors was given in Chapter 1 and is written again below.

'Making it easy to do the right thing'.

(Bromley 2010)

To move forwards with continued improvements in patient safety, including the use of clinical simulation educational interventions, requires all healthcare staff, both clinical and non-clinical, to have an almost 'programmed' or 'instinctive' understanding of 'human performance characteristics' or 'Human Factors' and the situations under which they and others are more likely to make 'error' is more likely (Sections 1.4 and 3.2). I think failure to have this understanding is one of the root causes of a failure to engage with colleagues in the practice of collaborative teamwork. Confidence in our roles and the self efficacy to perform specific clinical tasks must remain but can be reframed as 'confidence with humility'. In the literature review it was shown that where CRM knowledge was tested before and after a simulation, the self reporting of some knowledge was lower after the simulation (Mikrogianakis et al., 2008). This represents an effective way of demonstrating to staff their own individual gaps in essential orientation and to help encourage humility and motivate their learning to reduce the errors associated with these gaps. The classification of 'error' or 'gaps' is also vital; the difference between those errors that are a result of human error as originally defined by Reason (J. Reason, 2000) and those that are a result of knowledge or skills or rarely negligence need to be clearly made. The solutions that will prevent harm secondary to human error are very different to the solutions that are necessary because of failures in training and this is an area that is not always well understood or implemented.

The relationship between the quality and patient safety department of hospitals and those responsible for the education of staff needs to be established on the basis of mutual respect and trust (as with the relationship of different professionals). The essential and complementary roles of both departments must be acknowledged in moving a health care environment towards resilience. Will an 'Orientation to Resilience' mean that clinical risk data no longer needs to be collected? I think there is likely to be a persistent gap between what is theoretically achievable in healthcare with what is practically possible with current funding. Consequently there is always going to be a need to prioritise interventions and a knowledge of an organisations own 'fingerprint' of harm will be important to guide these interventions. This fingerprint will also change with time. An organisational safety audit will also continue to provide data about the effectiveness of interventions to improve efficiency.

9.2 Simulation: Within the continuum and curriculum of education

It is now common practice for Professionals who work in healthcare to complete study or reflection on practice, both of which contribute to their Continuous Medical Education (CME) or Continuous Professional Development (CPD). This represents an acknowledgement that learning continues throughout life both personally and professionally and this is overseen, in Medicine for example, by the DHBs, the Medical Colleges and the New Zealand Medical Council.

Simulation is an exciting form of education and has attracted many advocates who see the similarity with workplace experience but not all of these advocates have either experience or qualifications in education. This theme of 'within the continuum and curriculum of education' aims to describe whether the simulation intervention was implemented in a way that was grounded in educational theory, as described in Chapter 3, and whether there were links with other non simulation educational interventions in a professional or departmental curriculum.

9.2.1 Grounding in educational theory

An Overarching Curriculum with Aims and Objectives

The development of a new eduational curriculum such as one to address the area of patient safety should itself follow clear educational principles including a robust needs analysis. An example of a well executed needs analysis with curriculum development was described (Zimmermann et al., 2015) and the importance of a patient safety curriculum was referred to in several papers (P. H. Weinstock et al., 2005) (Andreatta et al., 2011; Kotsakis et al., 2015). This patient safety curriculum can be considered as having implications both for an individual's continual professional development as well as the organisations continued development towards resilience. In considering the individual health practitioner, the learning outcomes with direct relevance to patient safety should either align with professional curricula already in existence, such as those of the Professional Colleges or Councils, or be an evidenced based strategy for change. The development of the Bristol Simulation Programme reflects the first of these (D. J. Grant & Marriage, 2012) and this may represent a model for New Zealand.

In designing a Paediatric Simulation Program examples of national standards that should have a role in guiding the design of the curriculum would include the educational curricula of the Professional Colleges as well as definitions of good standards in healthcare such as those of the New Zealand Medical Council (NZMC). The NZMC has published standards for Good Medical Practice which includes 84 standards for care, 3 examples of which are below:

- Work collaboratively with colleagues to improve care, or maintain good care for patients, and to ensure continuity of care wherever possible.
- Make sure that your patients and colleagues understand your responsibilities in the team and who is responsible for each aspect of patient care.
- You must be competent in each professional role you hold. You must follow relevant guidance, including the guidance published by the Council, and continue to develop your knowledge and skills. This applies to all doctors, and to all aspects of your medical practice including management, research and teaching.

Clinical simulation is an educational tool that should be targeted at those complex learning outcomes that require repetitive practice. It is a resource intensive tool, both for equipment and personnel and should therefore be reserved for those situations where the outcomes cannot be met with alternative methodology. This may include orientating to an environment, development of non technical skills, identification of system errors and practicing complex clinical situations rarely seen in practice. Simulation can also be used to assess departmental performance such as the preparedness and competency in paediatric resuscitation of an emergency department (Hunt, Hohenhaus, Luo, & Frush, 2006) (Hunt et al., 2007).

In considering the learning curriculum of a specific profession or department clinical simulation should be embedded within a wider educational curriculum that incorporates blended learning, that is a variety of educational techniques, where each technique is targeted towards the most appropriate learning outcomes. It was not always clear from the literature whether this was the case and my concern is that clinical simulation can be developed independently of other departmental learning opportunities which raises concerns around efficiency as well as consistency of learning outcomes.

In this literature review the objectives of the interventions reviewed were based around teamwork and included the assessment of teamwork and the establishment of interprofessional and inter departmental relationships or rehearsal of standardised communication processes. These are discussed in more detail in the following section. An initial aim in the establishment of a sustainable simulation program can be as simple as an introduction to simulation with the purpose of establishing staff engagement. In the early part of the establishment of a simulation program this is extremely important as the anxiety associated with being the subject of a simulation exercise can undermine a simulation program if not correctly managed.

Faculty Training

Clinical simulation involves health practitioners being placed in a vulnerable situation where they are observed and critically assessed before receiving feedback about their performance. Many of us as health practitioners are emotionally as well as cognitively engaged with our work and aim for perfection, often being self critical.

Those that develop and run clinical simulation courses should be well trained in the skills that maximize learning and minimize ongoing emotional distress. The strategy of the

SIMPeds course exemplifies this approach with the development of super facilitators. The SPRint course has followed a similar model.

Knowledge and technical skills: foundation and integration

The management of a clinical deteriorating child or one that has suffered a respiratory arrest requires a wide range of knowledge as well as skills. If the aim of a clinical scenario is to practice and receive feedback on predominantly the non-technical skills then it is important that those participating have a foundation knowledge base and the appropriate technical skills in order to optimise the non-technical learning. If this is not the case then there will be distracters both within the scenario and the debriefing, which will affect learning. The knowledge or technical skill competency is often assumed because of the level and experience of the healthcare practitioners but is not always realized in practice and this was confirmed in a number of the articles reviewed (Hunt et al., 2008) (Geis et al., 2011) (O'Leary et al., 2014). In some of the educational interventions identified in the literature aspects of the relevant knowledge were distributed in advance of the simulation. This included the use of e learning or the provision of a tutorial or discussion on the day of the simulation. Both of these methods were also used by SIMPeds and SPRinT programs. The e learning methodology can be considered as a flipped classroom technique that is a method that has become increasingly popular in secondary and tertiary education. It is defined below:

Flipped Classroom Technique

'Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter'. It developed as an approach from the ideas of a number of educators that included Lage, Platt and Treglia (Lage, Platt, & Treglia, 2000).

This approach is being increasingly used and referred to within healthcare as an efficient and effective strategy to facilitate learning.

A similar concept is Team Based Learning (TBL) that was originally developed by Larry Michaelson in the 1970s and continues to be developed in ways that include a role in healthcare (Michaelsen, Parmelee, McMahon, & Levine, 2008). This is defined below:

TBL (http://www.teambasedlearning.org/)
'Team-Based Learning is an evidence based collaborative learning teaching strategy designed around units of instruction, known as "modules," that are taught in a three-step cycle: preparation, in-class readiness assurance testing, and application-focused exercise.'

Both of these approaches work to ensure that knowledge is presented prior to a specific educational session and, in the case of team-based learning, the acquisition of that knowledge is confirmed with a quiz prior to progressing to an application of that knowledge. When considering resuscitation, this can be used to confirm core knowledge as well as specific guidelines or protocols. It may also be possible to use a similar pedagogical approach in the confirmation of essential technical skills prior to a simulated scenario. This may be done in advance of the simulation sessions or as part of the preparation for the scenario and could include an evaluation of the efficiency of these skills as well as individual or departmental competency. The timely application of these skills is known to have an important part to play in patient outcome (Cooper & Cade, 1997; Herlitz et al., 2002) and competency in technical skills was demonstrated in some of the educational interventions I personally observed prior to the clinical scenario.

The provision of high quality clinical simulation is resource intensive, both from an equipment point of view and the personnel resource required to run simulations effectively. In implementing a simulation program there should be extensive use of blended learning strategies with the opportunity to both revise and acquire new knowledge as well as be assessed in that knowledge and the technical skills deemed necessary for the clinical simulation. The only time where this is not necessary is where the purpose of the clinical simulation is to highlight gaps in knowledge and skills (Hunt et al., 2007) (Mikrogianakis et al., 2008).

Characteristics and Structure of Educational Session

The educational sessions identified in the literature review occurred both in simulation centres and In-Situ and the characteristics of these sessions were usually different; those that occurred in the simulation centre were more likely to be part of longer education sessions while those that occurred In-Situ were shorter. All of the SIMPed and SPRinT sessions observed were classed as In-Situ and some of these were planned and announced and included tutorial and discussion time within a seminar room as well as the clinical scenario. There were other sessions that consisted of an introduction, simulation scenario and debriefing only and these tended to be unannounced but expected. Both of these patterns were also demonstrated in the literature. The frequency and length of simulation sessions showed considerable variability as did the frequency with which any healthcare worker was mandated or had the opportunity to attend. In the published In-Situ clinical simulation interventions the regular institution of sessions was associated with the most clinical benefit (Andreatta et al., 2011; Theilen et al., 2013).

In my informed opinion a combination of both occasional simulation centre and frequent In-Situ sessions are necessary to promote the largest clinical benefit. A single formal educational session of at least 4 hours provides the opportunity to improve confidence, to consolidate knowledge and technical skills as well as encouraging cognitive reflection on the clinical scenario and experiences in practice. This fits the cycle of learning as postulated by Kolb. It can also serve to orientate and motivate staff towards participating in the In-Situ simulation. Orientation to the processes of simulation and to the fidelity characteristics of the manikin is an important aspect of promoting engagement. However, these occasional educational interventions are not sufficient to see significant improvements in team based behavior in a similar way to the fact that resuscitation courses have a role in improving resuscitation knowledge and skills but are not sufficient to key technical skills (Jabbour et al., 1996) (Jewkes & Phillips, 2003). These sessions need to be followed by frequent opportunities to participate in regular In-Situ simulations with debriefing and feedback such that healthcare workers are 'conditioned' in their responses. There is concern that experience without feedback improves confidence but not skill, a potentially dangerous situation, and it was noted in the literature that some participants would leave an insitu simulation session before completion of the debriefing (Wheeler et al., 2013). There is a strong argument for developing a well organised system of peer review observation in the clinical work place and feedback in parallel with the development of a simulation program.

The exact clinical situations differed although the commonest clinical scenario was that of a paediatric arrest or code. The scenarios observed at SIMPeds were a paediatric arrhythmia and a neonate with necrotizing enterocolitis and the scenario observed at SPRinT was a cyanotic spell associated with the cardiac condition Tetralogy of Fallot. The length of the clinical scenarios varied and it is interesting that both the SIMPeds and SPRinT courses advocate stopping the scenario before all the medical intervention has been completed when emotions remain high but where the aims of the scenario have been met. This emotional engagement emphasises the reality of practice and provides a rich foundation for reflection and debriefing.

Debriefing

In the majority of the educational interventions the clinical simulation was followed by an opportunity to debrief and the commonest debriefing tool referred to was that of the advocacy inquiry model (Chapter 5 5.5). This is the method that was also used on the SIMPeds and SPRinT courses. It is a method that requires significant practice and without observing its use in the educational interventions published it is difficult to know how well it was used. The effective use of this tool requires not only a clear *understanding* by all faculty and the candidates of the basic assumption but for the *ability* of faculty to deliver the feedback in a way that reinforces that philosophy – this requires practice, a supportive environment and mutual respect. I observed this tool to be used well in both the SIMPeds and SPRinT courses although the standard varied between faculty members.

Interprofessional Role Modelling

The intention was to study educational initiatives that fulfilled the true definition of interprofessional. In the literature review it was clear that the intention was for many of the initiatives to be interprofessional and the candidates were often from a variety of professions but it was not always clear if the faculty were from different professions. The

SIMPeds sessions were interprofessional as were the SPRinT sessions, and I particularly like the fact that the SPRinT sessions were led by a nurse educator with support from the medical consultant. It is common in my experience for those from the medical profession to lead when they are involved and I am not sure that this helps to model and validate the contribution of other professions and flatten the professional hierarchy.

9.3 Teamwork: Defining and Evaluating

The concept of teamwork was a central requirement to this work and builds on the knowledge of human factors as already outlined. There is increasing recognition of the importance of teamwork and communication within healthcare (Baker et al., 2006) (Kilner & Sheppard, 2010; E. Salas, Wilson, Murphy, King, & Salisbury, 2008). This is partly a function of the increasing complexity of the health needs of patients as well as the increasing number of medical specialties, restrictions on working hours and the consequent multiple hand overs between teams. The literature has recognised that poor communication and teamwork are responsible for a large proportion of patient harm.

The theme of 'Teamwork: Defining and Evaluating' aims to describe aspects of communication, teamwork or CRM that were studied within the literature review or observed at the two International Centres of Excellence.

9.3.1 Definition of CRM and Teamwork

The definition of CRM is clear (Section 5.4) and the specific factors that are included within that definition are also well described. As there are now 15 factors included in the definition there is likely to be some variation between papers about which factors are specifically taught within a specific clinical simulation session. If there is an attempt to facilitate a depth of understanding in all 15, this may be a little too many to guarantee either memorizing or effective learning of the principles of each. Most people do have a 'gestalt' understanding of the term teamwork but the individual components necessary are not always well understood or described, although there is some consistency around aspects of communication, which was discussed in the background to this work (section 5.4.4 and 5.6) and includes;

- Pre-briefing
- Call out
- Closed Loop Communication
- Standardised communication tools such as ISBAR

It is my experience that the term 'closed loop communication' may be understood (knows and knows how of Millers Triangle) but it is not always adhered to in either simulation or within the workplace (shows or does). The language of teamwork, another important aspect in communication, is not always standard between departments and professions and even professions working together within the same department sometimes use different language. The use of 'common' terminology that is universally understood is obviously crucial to minimise misunderstanding or miscommunication. In the literature review there were differences between educational groups as to which elements of teamwork were prioritised. These elements overlap with the specific factors included in CRM and include:

- Leadership
- Followership
- Mutual professional respect
- Problem Identification
- Decision Making
- Workload distribution
- Situational Awareness
- Mental model
- Time management
- Conflict resolution
- Mutual performance monitoring

These terms themselves sometimes need to be clearly defined in order to ensure that all those working together within a team are working to the same definitions. There was a significant overlap between the areas of teamwork or CRM emphasized on the SIMPeds course and the SPRint courses. This is not surprising as the SPRinT courses were developed from the Boston model. These courses emphasized the importance of 'managing the critical event' which included the following terms with some brief definitions:

- Role Clarity
    - Including an event manager (or 'leader')
    - Those with other roles and responsibilities encouraged to cross monitor
- Communication
    - Address people directly
    - Use of non-judgmental tone (adhering to basic assumption)
    - Closed loop communication
- Personnel Support
    - Call for help early
    - Orientate new helpers
- Resources
    - Efficient use of equipment and personnel
- Global Assessment
    - Avoid fixation on specifics
    - Verbalise and review frequently

The Starship Paediatric Hospital in Auckland has developed a teamwork simulation course based on the Boston model that uses similar definitions.

A National Multidisciplinary Operating Room Simulation (MORSim) Intervention funded by the Accident Compensation (ACC) with collaborative support from the Health Quality and Safety Commission is also being developed within New Zealand (https://www.morsim.ac.nz/4.html). They have used the theoretical framework proposed by Salas ((Eduardo Salas et al., 2005) and prioritise the following aspects of teamwork:

- Leadership

- Team orientation,
- Mutual performance monitoring,
- Back up behavior
- Adaptability.
- Shared mental models
- Mutual trust
- Closed loop communication.

It would be important for other simulation interventions within New Zealand to have significant overlap and alignment with the Starship Hospital program and the MORSim project. Both regular audit and specific areas of research should also be implemented within simulation interventions to inform the relative contribution of each of these teamwork factors in improving patient safety, and to help to continue to develop our understanding of teamwork in the healthcare setting.

9.3.2 Engaging with Simulation in teamwork

The terms 'knowledge', 'skills' and 'attitude' are now widely used to describe a taxonomy of learning as originally referred to by Bloom (Bloom, Engelhart, J, Hill, & Krathwohl, 1956). It is generally thought that one of the challenges of education is to change an individual's attitude, and not all health professionals will have a positive attitude towards the need for simulation training or teamwork. It is critical to recognise this and work to motivate individuals towards improving their understanding of human factors and human error to understand the necessity for good teamwork. The importance of gentle supportive engagement must not be undervalued as the use of simulation can place healthcare professionals in a very vulnerable position that has the potential to result in their disengagement from the process. Orientation to the language and processes of simulation as well as adhering to clear educational principles with mutual respect during the simulation and debriefing is critically important. If this is adhered to then the simulation experience or the observation (using video) of an individual's behavior during simulation may have a role both in reinforcing a positive attitude or changing a negative attitude in a positive direction.

The literature review did demonstrate that simulation interventions had some effect in motivating healthcare staff to the importance of teamworking and questionnaires also demonstrated changing attitudes towards safety using the Safety Attitudes Questionnaire (Patterson, Geis, LeMaster, et al., 2013).

9.3.3 Confidence and Comfort

The terms 'confident' and 'self efficacy' are similar but not synonymous, with confident referring to a more generic feature of an individual and self efficacy referring to the individual's 'confidence' in their ability to perform a specific task. Self efficacy or confidence are regarded as essential in areas of sport and performance for example but are only recently being explicitly referred to within healthcare. There is an important conflict to acknowledge with confidence in healthcare, in that confidence is potentially a risk if it is not accompanied by true expertise in performance (Marteau, Wynne, Kaye, & Evans, 1990)and humility is also critical to the engagement with teamwork. The term self efficacy was not referred to directly within the literature but was inferred with self assessments regarding an individual's confidence in specific areas such as clinical assessment, recognition of a deteriorating patient, ability to perform procedures, participation in a code and leading a code.

It is likely that a well conducted simulation intervention with supportive debriefing that adheres to the basic assumption will improve confidence unless it is specifically designed to challenge this area. An improvement was referred to or demonstrated using questionnaires in the majority of innovations where it was studied (Bishop-Kurylo & Masiello, 1995) (Toback et al., 2006) (Allan et al., 2010) (Andreatta et al., 2011) (Figueroa et al., 2013; Stocker et al., 2012) (Kurosawa et al., 2014) (Kotsakis et al., 2015), which included in both arms of the Paediatric Advanced Life Support Training (Kurosawa et al., 2014) where one group had regular scenario practice and one group had the standard course. In one of the simulations where the simulation scenario demonstrated lack of knowledge there was still an improvement in confidence based on a post course questionnaire (Mikrogianakis et al., 2008).

The term 'comfort' was also used and this is likely to have a relationship with confidence and a candidate's ability to contribute actively towards the resuscitation of a child. Comfort scores for specific procedures as well as assessment and recognition of the deteriorating patient increased significantly following simulation training (Toback et al., 2006) (Allan et al., 2010; Katznelson et al., 2014). It has been highlighted a number of times in this paper that paediatric arrest is a rare event. The use of simulation to promote a familiarity and comfort with processes and protocols in this rare event should not be underestimated. The term 'outside of my comfort zone' is often used and can be a significant barrier to an individual's ability to help. There are some tasks that even the most inexperienced can contribute to.

9.3.4 Technical Skills

It was not the aim of this review to explore the area of technical skills except to acknowledge where they fit into the hierarchy of simulation training. These can be considered both as individual competencies necessary to fulfill individual clinical roles, as well as team task competencies necessary in the provision of optimal team functioning. This review confirmed a belief that the ability to perform technical skills associated with resuscitation is often assumed by others because of an individual's role, and this together with an individual's confidence being incongruent with their ability is a concern. The importance of timely and effective resuscitation leading to improved outcome is well described (Cooper & Cade, 1997; Herlitz et al., 2002) and suggests the importance of evaluating critical points within a simulated scenario with reference to time. Efficiency is likely to improve with good communication and teamwork.

9.3.5 Improvement in Teamwork or Team functioning

The importance of a lack of teamwork as contributing to observed sub optimal care was reinforced in those studies that described these observations during their simulation scenarios. This included areas such as role clarity, including that of leader (Hunt et al., 2008) (Wheeler et al., 2013), situational awareness and communication (O'Leary et al., 2014; Patterson, Geis, Falcone, et al., 2013). The value of teamwork in contributing to the efficiency of effective technical skills has also been alluded to above. There continues to be debate about how reliable simulation is in predicting clinical performance as well as whether simulation scenarios should be held within a a simulation centre or In-Situ. A recent study evaluated as part of the literature review has provided some evidence across the three contexts that the evaluation of teamwork using the TEAM tool showed similar scores for all three areas (Couto et al., 2015).

There was a wide variety in the exact way in which the team training was conducted, and not all studies demonstrated a clear improvement in team functioning despite this being one of the primary aims of using simulation for team based training. There are a number of factors that may have influenced this;

- The educational knowledge and skills of faculty together with their experience in simulation training as well as their professional identity:
    - Simulation should be grounded in educational theory and not purely clinical experience.
    - Experience with simulation, ideally with mentoring by more experienced colleagues facilitates the learning of techniques such as those of debriefing.
    - An interprofessional faculty is likely to improve engagement from multiprofessional staff especially where there is good role modeling from faculty of the interprofessional relationships
- The motivational, cognitive and emotional preparation of those participating:
    - One of the motivators for improving teamwork and crisis resource management is the realisation of the pervasive nature of human error and its applicability to every one of us.

    - It is important to confirm knowledge or technical skills prior to conducting simulation where non-technical or teamwork skills are being evaluated.
    - It is not clear whether all the participants involved in the team based scenarios had a clear understanding of what constituted teamworking and whether they were familiar with the specific tool or criteria being used to evaluate them.
    - Participation in simulation can be stressful and a 'psychologically safe' learning environment needs to be established.
- The clinical simulation intervention itself:
    - Simulations could occur within a simulation centre or In-Situ
    - It was not always clear whether there was orientation to the environment and manikins.
    - The time allocated to both the simulation session and debriefing varied significantly
        - The skills of teamworking or crisis resource management are both social and cognitive and may require intensive practice and personality-specific feedback as well as general feedback.
- The assessment method:
    - Videos of the simulation scenario were often used but the number and training of faculty scoring the videos and whether they were blinded to the video being pre interventional or post interventional was not consistent.
    - There was a wide variety of tools used to score and assess teamwork.

Those interventions that showed the most consistent improvement in teamwork (Auerbach et al., 2014) or patient safety (where improved teamworking is assumed to have contributed) (Andreatta et al., 2011) (Falcone et al., 2008) (Theilen et al., 2013) were those incorporating frequent well-conducted In-Situ simulations. However, improved teamwork was also seen in both groups involved in the Paediatric Life Support Recertification using the Behavioural Assessment Tool (BAT) with no significant difference between the two despite one group experiencing 'mass' practice (all scenarios performed on one day) and one 'distributed' practice (scenarios distributed throughout a 6 month period). This study demonstrated the effect of using different tools as the 'distributed' practice group did show a significant improvement in score using the Clinical Performance Tool (CPT) and this improvement was not demonstrated by the 'mass' practice group. The only other study that showed a significant improvement in teamwork was a study aimed at Allergy Clinics (J. L. Kennedy et al., 2013) where the intervention was a workshop with an opportunity to participate in four scenarios with a follow up unannounced In-Situ scenario. In this study teamwork was part of the assessment using the Clinical Emergency Preparedness Team Evaluation (CEPTE) adapted from TeamSTEPPS.

It is important to note that not all of the regular In-Situ simulation innovations described an improvement in teamwork and the reasons for this are not clear; In a study from a paediatric emergency department in Toronto it is not known whether health care professionals were able to participate or observe more than one simulation session although they were held monthly (Mikrogianakis et al., 2008). In the study from the emergency department in Cincinnati where simulation sessions were held weekly, there was no significant change in teamwork scores using ANTS (Patterson, Geis, Falcone, et al., 2013). The authors postulate that this was partially due to the high initial scores and the fact that the majority of the participants had previously participated in a simulation centre based course.

One of the roles within the team is that of the individual who leads, coordinates or manages the acute clinical event. This role can be referred to as:

- Leader
- Coordinator
- Event Manager

One of the evidenced-based recommendations for those undertaking this role is that they should not perform tasks or technical skills as this can distract them such that the event is not optimally managed. In spite of this it would seem that it is not uncommon for this to occur in simulated practice. This was alluded to in the literature review and I have also observed it in multiple simulations as well as within the workplace. This suggests that those managing or leading an acute critical event require additional training and practice in order to consolidate these essential skills. It was interesting to note that role definition and leadership are highlighted above communication as important teamwork learning outcomes following simulation (Andreatta et al., 2011).

Other important roles most commonly delegated to nursing staff include first responder and administering medication and fluids. In both of these situations the nursing staff may have multiple competing demands. As first responders awaiting the resuscitation team, it has been demonstrated that they can be distracted by preparing for the team's arrival rather than administering high quality cardiopulmonary resuscitation (Hunt et al., 2008). In an acutely deteriorating patient or one that requires resuscitation another specific area of concern in acute situations is the number of requests aimed at the nursing staff responsible for drawing up medication and fluids (Geis et al., 2011). This is a crucial area with significant potential for error especially in paediatric practice where drug doses are calculated based on weight. At present in New Zealand this is often calculated by the individual prescriber although automated systems are being implemented. An acute team needs to include at least two nurses that have skill in the drawing up of medication and fluids to ensure that this is done safely and efficiently with clear checking processes.

9.3.6 Teamwork Tools

There were a variety of behavioural tools and checklists used within the literature review that include those mentioned in the background chapters such as ANTS (Patterson, Geis, Falcone, et al., 2013). It was not always clear whether these tools had been validated for use within the specific healthcare contexts being studied or whether faculty had had specific training to increase the reliability of the tool. In a similar way to the variation noted above in defining what behavior contributes to teamwork, there is significant overlap with the behavioural markers used in these teamwork tools. The SIMPed and SPRinT courses did not use specific behavioural tools but did use checklists with clear definitions and the faculty had a clear understanding of these definitions. The MORSim project uses the Behavioural Marker Risk Index (BMRI), which is shown below (MORSim source).

Figure 11: MORSim Behavioural Markers (J. M. Weller et al., 2016)

Domain	Description
Briefing	Situation / relevant background is shared; patient, procedure, site/side are identified; plans are stated; questions are asked; ongoing monitoring and communication is encouraged
Information Sharing	Information is shared; intentions are stated; mutual respect is evident; social conversations are appropriate
Inquiry	Input and other relevant information is asked for
Contingency Management	Relevant risks are identified; back up plans are made and executed
Assertion	The members of the team speak up with their observations and recommendations during critical times
Vigilance	Tasks are prioritized; attention is focused; patient/equipment is checked, monitoring is maintained; tunnel vision is avoided; red flags are identified
Inter-disciplinary information sharing	Information is shared between the surgical, anaesthesia and nursing teams

The use of a well validated tool does enable comparisons to be made in different populations over time or between populations in quantitative studies of patient safety, which is obviously very useful. There are several reasons why it is difficult to compare some of the results regarding teamwork within this literature review, but these include the use of different tools under variable conditions. In considering a specific paediatric context, such as a general paediatric context of Christchurch Hospital with input from the Emergency and Intensive Care department, it may be useful to further evaluate and develop one of these tools. This will require validation and reliability studies to develop a simple but robust tool for use under these conditions. There are also disadvantages of using specific tools. These include focusing on areas that have already been identified and it is also useful to continue to use qualitative descriptive methods that may uncover aspects important in patient safety that may have not been previously recognised.

9.3.7 Communication and Collaboration

Communication and collaboration are both areas that can be included within teamwork but deserve special mention; the collaboration between medical and nursing staff using simulation and a specific collaboration tool (Schmalenberg Nurse-Physician Scale (KSNPS)) showed significant improvement following the opportunity for the same team of physicians and nurses to engage in simulated scenarios and debriefing (Messmer, 2008). In this study the objective assessment of collaboration using the KSNPS tool showed significant improvement in comparison to the self assessment tools completed by those involved. This again emphasises that there is not infrequently a disconnect between how we subjectively perceive ourselves and how we objectively perform. In contrast a study that concentrated the debriefing on communication showed improvement in both the assessment by investigator-scored videos and self assessment over the course of three scenarios run over three months (Nwokorie et al., 2012).

Communication was the commonest causal factor in the study from Australia that aimed to identify incidents of sub optimal care(O'Leary et al., 2014). Examples of difficulties in communication highlighted in other papers included difficulties in communicating areas of concern (Patterson, Geis, Falcone, et al., 2013) as well as failure to use processes such as closed loop communication (Zimmermann et al., 2015) reflecting my own clinical experience. Improvements in these areas following simulation was also demonstrated (Allan et al., 2010; Figueroa et al., 2013). The monitoring of colleagues and tasks with cross checking is an important role within teams that acknowledges human fallibility but it is of little use if those that are monitoring are unable to communicate their concerns (Burke, Salas, Wilson-Donnelly, & Priest, 2004). The development of specific language and communication processes that include leaders behaving in a way that facilitates communication is of paramount importance. It is highly like that improved communication skills were responsible for some of the improvement in patient safety demonstrated in studies where communication was not explicitly assessed (Andreatta et al., 2011; Theilen et al., 2013).

9.3.8 Teaming

The area of an individual's skill in 'teaming' was not encountered within the literature review or during the visits and it is an area that requires further research. In many areas teams are 'unstable' and are constructed and deconstructed depending on the situation. Differences of opinion are inevitable in healthcare and disagreements will occur during the emotionally charged situation of an acute clinical crisis. All of those involved in working together during a paediatric crisis have a collective sense of responsibility for the care of the patient and need to practice the skill of negotiation to achieve the best outcome for the patient. This is difficult and requires practice, perhaps even with the use of scripting of specific replies and this is an area that contributes to the skill of teaming.

9.4 Evaluation: intervention and self-assessment

Any intervention, particularly one that requires a significant financial and resource input should be thoroughly evaluated. Kirkpatrick has described levels of evaluation (Kirkpatrick & Kirkpatrick, 2007) and this model is being increasingly used in healthcare (Craig, Hall, & Philllips, 2016; Hammick et al., 2007). The ultimate aim of establishing a paediatric interprofessional simulation program would be to evaluate at level 4 (Chapter 5) demonstrating improvements in patient safety. It is clear that evaluating at level 3 and level 4 requires organisational planning which itself requires a significant financial and personnel resource input.

This theme aimed to describe the way in which clinical simulation interventions as a whole, teamwork and individuals were evaluated and what the results of that evaluation are:

9.4.1 Kirkpatrick Level 1 and 2

Kirkpatrick level 1 and level 2 were the commonest ways in which clinical simulation interventions were evaluated (Allan et al., 2010; Andreatta et al., 2011; Bishop-Kurylo & Masiello, 1995; Messmer, 2008; Mikrogianakis et al., 2008; Toback et al., 2006; Volk et al., 2011) (Figueroa et al., 2013{Patterson, 2013 #664; Stocker et al., 2012) (Wheeler et al.,

2013) (Auerbach et al., 2014; Katznelson et al., 2014; Kurosawa et al., 2014). (Couto et al., 2015) (Kotsakis et al., 2015). This usually took the form of questionnaires that were completed by the participants following the intervention, which were often primarily aimed at evaluating a participant's enjoyment of a session (level 1) but some also asked for the participants perception regarding specific aspects of learning (level 2)(Mikrogianakis et al., 2008) (Stocker et al., 2012) {Figueroa, 2013 #641} (Katznelson et al., 2014). The majority of simulation sessions reported a positive evaluation by the participants and the importance of this type of evaluation should not be underestimated, as it is an important predictor of engagement and motivation to learn.

The complicated relationship between confidence (self efficacy) and competency has been referred to but deserves further discussion here: The term psychomotor is often used to describe technical clinical skills and this term is constructed from psych (meaning self) and motor (movement) which illustrates the close relationship between our cognition and application. The importance of self efficacy in carrying out a skill within the clinical environment, especially under pressure, cannot be overestimated, but we also require insight into those areas that we are not proficient in - to avoid being unconsciously incompetent. Improved confidence and / or comfort was demonstrated in several studies (Bishop-Kurylo & Masiello, 1995; Toback et al., 2006) (Allan et al., 2010; Mikrogianakis et al., 2008) (Andreatta et al., 2011) (Figueroa et al., 2013; Kurosawa et al., 2014; Stocker et al., 2012) (Katznelson et al., 2014; Kotsakis et al., 2015) but the validity of this confidence was questioned in 1 study (Katznelson et al., 2014; Kurosawa et al., 2014).

There was also evidence that the provision of clinical simulation decreased anxiety of health professionals whose clinical experience of paediatric emergencies was limited (Toback et al., 2006) which is of specific reference within New Zealand because of our population and geography, as many local services will be provided by skilled generalists. Anxiety is a strong emotion that can undermine an individual's confidence and prevent active participation in a clinical situation where the individual may have a significant role to contribute.

The use of self-evaluative questionnaires to assess knowledge and skills may also be associated with an element of self perception bias that relates to the participants experience and confidence, but in other studies improvement in these areas was objectively demonstrated (Cheng et al., 2013).(J. L. Kennedy et al., 2013). The demonstration of improved teamwork can be considered as fulfilling Kirkpatrick level 2 or 3 depending on whether these are conceptualised purely as skills or as changes in behavior. Although in its purest form this behavior change refers to changes observed in the workplace, there is increasing evidence that behavior change within clinical simulation does transfer to the clinical area and as such I have chosen to consider this as Kirkpatrick level 3.

9.4.2 Kirkpatrick level 3 and 4

It was less frequent for the intervention to be evaluated according to Kirkpatrick level 3 and level 4:

There were improvements in teamwork scores (level 3) in some studies using a variety of different methodologies (Falcone et al., 2008) (Auerbach et al., 2014; Couto et al., 2015; J. L. Kennedy et al., 2013; Kurosawa et al., 2014; O'Leary et al., 2014; Stocker et al., 2012). There was specifically evidence of improved understanding of the importance of leadership and communication (Allan et al., 2010; Cheng et al., 2013; Nwokorie et al., 2012). There was also evidence of improvement in the execution of essential tasks (Hunt et al., 2007) as well as the efficiency with which these tasks were performed, both of which are likely to rely on changes in behaviour (Theilen et al., 2013). In some of the studies the participants were contacted for follow up information regarding changes in their behavior and the SIMPeds program encourages past participants to share experiences of when they feel care has improved as a direct response to their simulation experience.

Kirkpatrick level 4 equates to changes within the organisation, the most critical of which is an improvement in patient care but other changes are also valid. The most convincing evidence of improvements in patient outcome came from two studies that described frequent, regular, sustainable In-Situ sessions (Andreatta et al., 2011; Theilen et al., 2013) which provides strong evidence to support the development of a paediatric simulation program. This may include aspects that demonstrate changes in behavior (level 3) as well as improvements in patient care (level 4). A combination of robust data as well as personal stories is a powerful combination but there may also be a role for peer review within the workplace. This could either be done in person or with the use of video data and would require clear professional and ethical guidance to protect both the professional and patients involved.

9.5 Embedding resilience and sustainability

It is clear that clinical simulation innovations are often created by enthusiastic clinicians and depend on those individuals rather than departmental or organizational commitment. The strong association of an individual is a risk for sustainability, although personal communication has led me to believe that this may be the first step towards organizational engagement. In contrast others have verbalized a need for planning and resourcing from the outset. An intervention that has a well-described and evidence-based purpose needs to be both sustainable and flexible to develop in parallel with the needs of the organisation. This defines resilience. The final theme of 'Embedding resilience and sustainability' obviously overlaps with the first theme particularly and aims to discuss the evidence for continuation and sustainability of the initiatives outlined in the literature review as well as the SIMPeds and SPRinT courses.

The SIMPeds program is probably the best example of an embedded sustainable program with high levels of departmental engagement and managerial support. It began because of the enthusiasm of an individual, and the staffing and governance have increased exponentially over recent years. Simulation at Cincinnati Children's Hospital also featured significantly within the literature review, suggesting that their simulation program is also currently sustainable (Falcone et al., 2008; Patterson, Geis, Falcone, et al., 2013) (Couto et al., 2015; Patterson, Geis, LeMaster, et al., 2013; Wheeler et al., 2013). Both of these examples suggest that a hospital wide initiative that incorporates an adequately resourced simulation program within a wider patient safety program is the optimal way to ensure sustainability and this is something that should be strongly considered within Christchurch. The support of Critical Access Hospitals or Primary Care by the donation of equipment and facilitating the development of regular simulation programs (Toback et al., 2006) (Katznelson et al., 2014) can be considered as having a part to play within New Zealand.

Although the intention of most of the other initiatives was to continue their initiatives, in a rapidly changing healthcare environment with fiscal constraints there will always be challenges in establishing and sustaining robust effective simulation programs and these challenges include:

- Stakeholder engagement
    - In some simulation programs there may be more than one organization involved (eg undergraduate and postgraduate)
    - Organisational leads and managers
    - Each department
    - Patients and families, individually or as part of consumer organisations
- Physical environment
    - Simulation centre or In-Situ space for conducting clinical simulation
- Financial Cost
    - Initial purchasing of equipment
    - Physical space
    - Recurrent maintenance and replacement costs
    - Personnel Resources to run and implement
    - Funding staff to attend
- Development of Faculty

In the scheduling of In-Situ sessions there should be an expectation of cancellation, particularly in the Winter Months when Children's services are stretched. In order to minimise unnecessary cancellation it is useful to establish clear criteria, which should lead to a cancellation. Short term patient care is obviously a priority but benefit to long term care as well as the resource implications of arranging an In-Situ session must also be considered.

9.5.1 Stakeholder Engagement

The term stakeholders is one commonly used in business to describe all those individuals and groups of individuals that have a 'stake' in the business development and success. In referring to healthcare it can be argued that all tax payers and potential users as well as healthcare workers are important stakeholders. The role of taxpayers, past, current and potential users of healthcare in the development of a simulation program was not investigated as part of this thesis. It is an area that is receiving more attention with the ACC funding of the MORSim project and is likely to be more fully investigated in the near future.

9.5.2 Physical environment: Program not Centre

The literature review identified articles where the educational innovation had been conducted at a Simulation Centre (or laboratory) or In-Situ. Both methods have strengths; conducting simulation in a simulation centre emphasizes the educational nature of the simulation and usually means that staff have been released from clinical duties, while In-Situ programs emphasise the workplace context and are able to highlight contextual system errors. There are advocates for one over the other but the use of the term 'Simulation Program' is a more unifying term that emphasises the importance of function and not physical location. One of the fundamental requirements of a successful simulation program is time taken to develop professional relationships, both within faculty and between faculty and departmental educational leads. This may be conceptualized as the development of an ecosystem with nodes of activity, and was particularly well articulated to me by Professor Peter Weinstock who established SIMPeds .

9.5.3 Financial Cost

The financial costs of establishing a clinical simulation program were described in several papers and there are different financial models to consider. This initial financial outlay must be balanced against expected savings from improved patient care, as well as against the psychological consequences of patient harm for patients, families and staff. The support from insurance companies in the United States of America, and the recent financial backing of MORSim by ACC provides suggests that more organisations acknowledge that there is evidence of cost savings with an embedded sustainable and well run simulation program.

9.5.4 Educational Faculty Training

A significant number of centres in the USA, UK and Australia and New Zealand now offer Simulation Instructor Training Courses in a similar way to SIMpeds and SPRinT (discussed below). Some of the larger centres, which include SIMPeds and the Center for Medical Simulation (CMS - also in Boston) also offer formalized ‘partnerships’ to help establish international centres of excellence. Starship Hospital, Auckland, has formed such a relationship with the SIMPed program and now has a Director for Simulation, Mike Shepherd, who is also currently the President Elect of the International Paediatric Society (IPSS). IPSS also offers support in this area with its global initiatives.

10 Conclusion

This chapter contains some concluding principles regarding the establishment of a Paediatric Interprofessional Simulation Program developed from the literature review and observation of expert practice. The final section briefly considers some gaps in the literature identified as part of this work.

10.1 Final Conclusions

A systematic Review of In-Situ Simulation has recently been published (Rosen, Hunt, Pronovost, Federowicz, & Weaver, 2012) and some of these conclusions validate this work. It is likely that the evidence explored within this thesis significantly overlaps with evidence from other contexts outside of paediatrics in the area of teamwork. A recent review of teamwork in the intensive care unit substantiates this (Dietz et al., 2014). There is additional literature where the concept of teamwork is studied in specific professions as well as departments (intraprofessional rather than interprofessional) and there is also work within the undergraduate field. The cognitive and social skills necessary for effective teamwork, collaboration and communication are likely to have broad similarities in a wide variety of contexts, although specific skills are likely to need emphasis depending on the departmental or professional context and the specific clinical situation.

It was not possible to identify without doubt the most effective way to improve interprofessional teamwork using simulation during this thesis. The educational initiatives described often had some similarities but were not implemented in an identical way, and gaps in the literature are elaborated on briefly in section 10.2. It is also important to recognize that in our current climate of healthcare we are unlikely to be able to recognize the contribution of one isolated initiative, as in reality we are constantly developing initiatives designed to improve care. An interprofessional teamwork simulation project should both align and integrate with other safety initiatives and each of these should be used to reinforce and develop complementary principles. It is likely that as our patient-centred services continue to improve, any innovation will only be responsible for what has been termed marginal gains.

The development of a systematic approach to evaluation should accompany the establishment of a simulation program to ensure that the allocation of resources, both financial and time, is validated. Although I recognize the importance of evaluating individuals, I wonder whether we should start to de-emphasize this within a teamwork framework? Of course each of us as health professionals does need to be evaluated but there is a risk of continuing to drive competition between all of us on the same team. I would be particularly interested in researching the teamwork behaviour exhibited by particular departments during both acute and non acute care. This approach would be particularly valuable in those teams that remain relatively 'stable', but a complementary approach that may be of particular benefit in the 'unstable' teams would be to develop the 'Teaming" skills of individuals. This may have to start at an undergraduate level in preparation for postgraduate service.

The following section (10.2) contains a series of recommendations for practice based on this thesis as well as personal experience and the final section summarises some gaps in the literature.

10.2 Recommendations for Practice

An interprofessional teamwork simulation program is defined here as a program that uses the educational concept of simulation to improve the skills of teamwork and CRM, regardless of location or profession. The following 10 core principles are those that I conclude are core in the establishment of this type of program.

1. An interprofessional teamwork simulation program should be recognized as an integral part of an organizational quality improvement and patient safety program in the establishment of a wrap-around patient-centred service

    a. This requires a close liaison between the organizational leadership as well as the Quality and Safety department and Educational departments.
2. A needs analysis should be conducted. This will include reference to the literature as well as to the 'needs' and 'wants' of the organization as a whole as well as to departmental and professional specific contexts.
3. An interprofessional teamwork simulation program should be developed with reference to educational theory and evidence base.
    a. This program must link with other organizational initiatives on human factors, teamworking and communication
    b. Educational theory should be used to underpin the program:
        i. Faculty training
        ii. Simulation Session design
        iii. Simulation scenario design
        iv. Debriefing
4. A simulation program should be developed as part of the wider educational curricula to meet the educational learning outcomes of individuals.
    a. The simulation program should be an integral part of the educational curricula of individuals as mandated by the respective colleges and national organisations.
    b. Clinical simulation sessions incorporate aspects of blended learning and use techniques such as the flipped classroom or Team Based Learning techniques.
    c. Standards of knowledge and technical skills are clarified and assessed either prior to or during a clinical simulation session.
    d. Simulation should be targeted at those learning outcomes where simulation is the most effective and efficient educational tool.
5. The professional and departmental leadership must engage with the simulation program and support the release of staff to run and attend.
6. The interprofessional teamwork simulation program should ensure that there are universal specific definitions, language and communication processes

    a. These need to be universally understood and used within all simulations in every department.
    b. These should be based on recognized standards used elsewhere and align with other simulation programs in New Zealand
7. The interprofessional teamwork simulation program will consist of sessions at both a simulation centre and In-Situ
    a. As a general rule unannounced In-Situ sessions should not be established within a department until the majority of that department have completed an introduction to CRM principles and the Simulation Program.
8. The simulation program should be established under strict condition of audit
    a. A continuous safety audit regarding key performance indicators of quality of patient care and patient safety.
        i. This will allow further development and refinement of the program to meet organizational and individual needs in the most efficient and effective way
    b. This will include evaluation of outcome using the Kirkpatrick levels.
    c. This may also include evaluation of faculty
9. The simulation program should also include the establishment of a research program to contribute to national and international literature.
10. Consideration should be given to the establishment of clinical workplace peer review using observation or retrospective review of videos. This should provide evidence to validate the simulation program.

10.3 Gaps in the Literature

The main gaps in the literature are those that relate to the specific characteristics of a simulation session as well as specifics relating to the simulation scenarios and the evaluation of effectiveness. These are briefly elaborated on below:

10.3.1 Organisation of Simulation Session

The time allocated to a Teamwork Simulation Session varied throughout the literature and this was also observed during my visits; The CRM NICU simulation that I observed in Boston was just over 4 hours and the CRM simulation session at The Royal Brompton was 2 hours. This is an area that requires further study, recognizing that there are a number of aims of a planned simulation education session which include:

- Role modeling a supportive interprofessional faculty
- Moving towards the creation of a 'just' culture
- Familiarisation with terminology
- Orientation to the mannekins
- Opportunity to practice scenarios under 'safe' educational conditions
- Opportunity for additional learning as highlighted within a scenario (eg policies and procedures)

It is likely that as the language and processes around CRM and teamwork become more familiar within an organization, the length of these initial CRM or revision sessions may be minimized. As the core language of teamwork as well as the skills of debriefing becomes embedded within an organization, these skills should be observed on a daily basis within clinical care. Policies in healthcare do continue to change and it may be that as the language and processes around CRM and teamwork become embedded, the simulation sessions may evolve to prioritise effective change management by the incorporation of scenarios that enable staff to 'test' new policies and processes.

10.3.2 Characteristics of Simulated Scenario

I do not want to go into detail about the clinical content of a clinical scenario as that is a whole new area. However, at present the literature does not demonstrate consistency around the length of time given for a scenario and the frequency with which scenarios should be repeated or the time given to debrief. It is likely that there is not a single answer to these questions. The answer is likely to be influenced by departmental culture, staff relationships as well as familiarity with the concepts of CRM and teamwork and the specific clinical situation. The use of simulation to maintain competency in core technical and nontechnical skills that have been *adequately learnt* is likely to need less regular repetition. It may be that infrequent simulation scenario practice together with clinical experience is enough, provided that the experience involves role modeling of CRM skills. This is known as *distributed practice.* The situation is likely to be very different with new skills as illustrated by the 'rapid cycle deliberate practice' method for learning technical skills. This method is entirely consistent with educational theory and there is no reason to suppose that the learning of CRM or non technical skills should be any different. This raises the issue of whether a second or third simulated scenario should follow debriefing to allow the opportunity to practice what has been discussed. These areas also require further research to maximize effect while minimizing inefficiency.

10.3.3 Evaluation of Teamwork

The importance of evaluation cannot be underestimated. This evaluation should be an organizational wide audit organized with reference to the Kirkpatrick model on a variety of levels, ranging from the individual through the department to the whole organization. It is not clear to me which 'Teamwork Tools', if any, should be used, and this requires further research. It may be that different tools are needed depending on specific contexts. The aim is obviously that the tool enables debriefing to focus on identified areas that have been shown to be important in patient care and that are amenable to behavior change.

As far as Kirkpatrick level 4 is concerned, as mentioned in the text of this thesis, simulation should be one component of an organizational wide safety innovation (1.2) and although the simulation in isolation may be responsible for what is known as marginal gains, the whole safety innovation should initially deliver significant improvements in care and then these improvements need to be sustained, ensuring the development of a resilient organization.

11 Reflecting on the Results

The aim of this project was to examine the evidence for interprofessional crisis resource management (CRM) or Teamwork simulation training in paediatric clinical care, to inform the development of a sustainable Paediatric Simulation Program within Canterbury which may ultimately extend within the South Island. I have concentrated specifically on the use of interprofessional simulation educational initiatives that focus on teamwork or crisis resource management in the paediatric patient who is acutely deteriorating or requires cardiopulmonary resuscitation. The methodology was predominantly qualitative and combined a review of relevant literature with direct observation of practice at two international centres.

In this Chapter I will share a brief critique of the methodology of the literature review and the non-participant observation based on my own personal experience and reflections as I wrote up this research.

11.1 Limitations of Literature Review

This was not a systematic review and is not presented as such. It was a targeted review conducted using a robust database search facilitated by a literature database expert. The review was deliberately limited to inter professional paediatric practice but it was accepted that there is likely to be significant overlap with results from studies of interprofessional clinical simulation in adult practice. The conclusions that refer to the most effective way to implement a sustainable and simulation program that results in improved patient care are likely to be similar.

11.2 Importance of context

There are a number of contextual points to consider when reviewing this information; the first is that the majority of the studies came from the United States of America (USA) which has a philosophically different funding model of acute health care to New Zealand (NZ). The USA system is predominantly one of private or insurance-based healthcare in comparison to the NZ system that is predominantly publicly funded. Paediatricians in the USA work both in primary, secondary and tertiary care and families often have a specific primary paediatrician who coordinates the care of their child. In contrast in NZ most primary care is delivered through a general practitioner, although there are some private primary care paediatricians. A second important point is that the majority of the studies were organised by specialist Paediatric Intensive Care or Emergency Departments. These departments have significant experience in the management of an acutely deteriorating child that would be in contrast to most paediatric departments within NZ. There is one paediatric intensive care unit in NZ that is located at Starship Hospital in Auckland in the North Island and serves the entire paediatric population of both the North and South Islands of New Zealand.

11.3 Non Participant Observation and Communication

The observation of simulation practice at two internationally recognized centres, as well as the opportunity for an ongoing relationship with these centres is highly valued. The methodology and its limitations has been previously described but following the experiences my own reflections are that it may have been useful to have taken more detailed field notes or to have audiotaped conversations. The disadvantage of this approach may have been to limit the flow of conversation and inhibit the interviewee and this is an important consideration as the conversations that I had flowed well and I believe contributed to the establishment of future professional relationships.

The visits were also arranged prior to completion of the detailed literature review and improved familiarity with the literature may have influenced, both in a positive or negative way, the observation and conversation during the visits. I think an ideal approach probably involves several visits with a combination of naïve questioning and observation prior to a detailed literature review and a follow up visit that has a more focused purpose after completion of a literature review.

12 Bibliography

Ali, J., Cohen, R., Adam, R., Gana, T. J., Pierre, I., Bedaysie, H., . . . Winn, J. (1996). Teaching effectiveness of the advanced trauma life support program as demonstrated by an objective structured clinical examination for practicing physicians. [Clinical Trial Randomized Controlled Trial Research Support, Non-U.S. Gov't]. *World J Surg, 20*(8), 1121-1125; discussion 1125-1126.

Allan, C. K., Thiagarajan, R. R., Beke, D., Imprescia, A., Kappus, L. J., Garden, A., . . . Weinstock, P. H. (2010). Simulation-based training delivered directly to the pediatric cardiac intensive care unit engenders preparedness, comfort, and decreased anxiety among multidisciplinary resuscitation teams. [Research Support, Non-U.S. Gov't]. *J Thorac Cardiovasc Surg, 140*(3), 646-652. doi: 10.1016/j.jtcvs.2010.04.027

Andreatta, P., Saxton, E., Thompson, M., & Annich, G. (2011). Simulation-based mock codes significantly correlate with improved pediatric patient cardiopulmonary arrest survival rates. *Pediatr Crit Care Med, 12*(1), 33-38. doi: 10.1097/PCC.0b013e3181e89270

Auerbach, M., Roney, L., Aysseh, A., Gawel, M., Koziel, J., Barre, K., . . . Santucci, K. (2014). In situ pediatric trauma simulation: assessing the impact and feasibility of an interdisciplinary pediatric in situ trauma care quality improvement simulation program. *Pediatr Emerg Care, 30*(12), 884-891. doi: 10.1097/PEC.0000000000000297

Ayres, L. (2008). Semi-structured interview. In lisa M Given (Ed.), *The SAGE encylopedia of qualitative research methods* (pp. 811-812). Thousand Oaks CA: SAGE publications Inc.

Baker, D. P., Day, R., & Salas, E. (2006). Teamwork as an essential component of high-reliability organizations. *Health Serv Res, 41*(4 Pt 2), 1576-1598. doi: 10.1111/j.1475-6773.2006.00566.x

Baker, D. P., Salas, E., King, H., Battles, J., & Barach, P. (2005). The role of teamwork in the professional education of physicians: current status and assessment recommendations. [Research Support, U.S. Gov't, Non-P.H.S.

Research Support, U.S. Gov't, P.H.S.]. *Jt Comm J Qual Patient Saf, 31*(4), 185-202.

Benner, P., Tanner, C., & Chesla, C. (1992). From beginner to expert: gaining a differentiated clinical world in critical care nursing. [Research Support, Non-U.S. Gov't]. *ANS Adv Nurs Sci, 14*(3), 13-28.

Benner, Patricia. (2004). Using the Dreyfus Model of Skill Acquisition to Describe and Interpret Skill Acquisition and Clinical Judgment in Nursing Practice and Education. *Bulletin of Science Technology Society, 24*(3), 188-199.

Bishop-Kurylo, D., & Masiello, M. (1995). Pediatric resuscitation: development of a mock code program and evaluation tool. *Pediatr Nurs, 21*(4), 333-336.

Bloom, B S (Ed), Engelhart, M D, J, Furst E, Hill, W H, & Krathwohl, D R (Eds.). (1956). *Taxonomy of Educational Objectives.* New York: David McKay Co Inc.

Burke, C. S., Salas, E., Wilson-Donnelly, K., & Priest, H. (2004). How to turn a team of experts into an expert medical team: guidance from the aviation and military communities. *Qual Saf Health Care, 13 Suppl 1*, i96-104. doi: 10.1136/qhc.13.suppl_1.i96

Calaman, S., McGregor, R. S., & Spector, N. D. (2010). How can we assure procedural competence in pediatric residents in an era of diminishing opportunities? The answer is simulation-based training. [Research Support, Non-U.S. Gov't]. *J Pediatr, 156*(6), 865-866, 866 e861. doi: 10.1016/j.jpeds.2010.02.058

Calhoun, A. W., Boone, M. C., Peterson, E. B., Boland, K. A., & Montgomery, V. L. (2011). Integrated in-situ simulation using redirected faculty educational time to minimize costs: a feasibility study. [Research Support, Non-U.S. Gov't]. *Simul Healthc, 6*(6), 337-344. doi: 10.1097/SIH.0b013e318224bdde

Cant, R. P., & Cooper, S. J. (2010). Simulation-based learning in nurse education: systematic review. [Review]. *J Adv Nurs, 66*(1), 3-15. doi: 10.1111/j.1365-2648.2009.05240.x

Cant, R. P., Porter, J. E., Cooper, S. J., Roberts, K., Wilson, I., & Gartside, C. (2016). Improving the non-technical skills of hospital medical emergency teams: The Team Emergency Assessment Measure (TEAM). *Emerg Med Australas*. doi: 10.1111/1742-6723.12643

Cartwright, Silvia. (1988). *The Report of the Committee of Inquiry into Allegations Concerning the Treatment of Cervical Cancer at National Women's Hospital and into Other Related Matters*. Auckland: Government Printing Office.

Catchpole, K. R., de Leval, M. R., McEwan, A., Pigott, N., Elliott, M. J., McQuillan, A., . . . Goldman, A. J. (2007). Patient handover from surgery to intensive care: using Formula 1 pit-stop and aviation models to improve safety and quality. [Research Support, Non-U.S. Gov't]. *Paediatr Anaesth, 17*(5), 470-478. doi: 10.1111/j.1460-9592.2006.02239.x

Cheng, A., Hunt, E. A., Donoghue, A., Nelson-McMillan, K., Nishisaki, A., Leflore, J., . . . Nadkarni, V. M. (2013). Examining pediatric resuscitation education using simulation and scripted debriefing: a multicenter randomized trial. [Multicenter Study Randomized Controlled Trial Research Support, Non-U.S. Gov't]. *JAMA Pediatr, 167*(6), 528-536. doi: 10.1001/jamapediatrics.2013.1389

Cooper, S., & Cade, J. (1997). Predicting survival, in-hospital cardiac arrests: resuscitation survival variables and training effectiveness. *Resuscitation, 35*(1), 17-22.

Couto, T. B., Kerrey, B. T., Taylor, R. G., FitzGerald, M., & Geis, G. L. (2015). Teamwork skills in actual, in situ, and in-center pediatric emergencies: performance levels across settings and perceptions of comparative educational impact. *Simul Healthc, 10*(2), 76-84. doi: 10.1097/SIH.0000000000000081

Craig, P, Hall, S, & Philllips, C. (2016). Using the Freeth/Kirkpatrick model to evaluate interprofessional learning outcomes in a rural setting. *Focus on Health Professional Education: A Multi-Disciplinary Journal, 17*(1), 84-98.

Curran, V. R., Sharpe, D., & Forristall, J. (2007). Attitudes of health sciences faculty members towards interprofessional teamwork and education. [Research Support, Non-U.S. Gov't]. *Med Educ, 41*(9), 892-896. doi: 10.1111/j.1365-2923.2007.02823.x

D A Kolb, R E Fry. (1975). Toward an applied theory of experiential learning. *MIT Alfred P. Sloan School of Management.*, 33-37.

Davis, P., Lay-Yee, R., Briant, R., Ali, W., Scott, A., & Schug, S. (2002). Adverse events in New Zealand public hospitals I: occurrence and impact. [Research Support, Non-U.S. Gov't]. *N Z Med J, 115*(1167), U271.

Davis, P., Lay-Yee, R., Briant, R., Ali, W., Scott, A., & Schug, S. (2003). Adverse events in New Zealand public hospitals II: preventability and clinical context. [Research Support, Non-U.S. Gov't]. *N Z Med J, 116*(1183), U624.

de Mos, N., van Litsenburg, R. R., McCrindle, B., Bohn, D. J., & Parshuram, C. S. (2006). Pediatric in-intensive-care-unit cardiac arrest: incidence, survival, and predictive factors. [Comment Research Support, Non-U.S. Gov't]. *Crit Care Med, 34*(4), 1209-1215. doi: 10.1097/01.CCM.0000208440.66756.C2

de Vries, E. N., Ramrattan, M. A., Smorenburg, S. M., Gouma, D. J., & Boermeester, M. A. (2008). The incidence and nature of in-hospital adverse events: a systematic review. [Research Support, Non-U.S. Gov't Review]. *Qual Saf Health Care, 17*(3), 216-223. doi: 10.1136/qshc.2007.023622

Dent, John A, & Harden, Ronald M (Eds.). (2005). *A Practical Guide for Medical Teachers* (Second ed.). London: Elsevier Churchill Livingstone.

Deutsch, E. S., Olivieri, J. J., Hossain, J., & Sobolewski, H. L. (2010). Medical simulation topic interests in a pediatric healthcare system. *Simul Healthc, 5*(5), 289-294. doi: 10.1097/SIH.0b013e3181f5c1c0

Dietz, A. S., Pronovost, P. J., Mendez-Tellez, P. A., Wyskiel, R., Marsteller, J. A., Thompson, D. A., & Rosen, M. A. (2014). A systematic review of teamwork in the intensive care unit: what do we know about teamwork, team tasks, and improvement strategies? [Research Support, Non-U.S. Gov't Review]. *J Crit Care, 29*(6), 908-914. doi: 10.1016/j.jcrc.2014.05.025

Edmondson, Amy C. (2014). Teaming *How Organisations Lear, Innovate and Compete in the Knowledge Economy*

Emanuel, L., Berwick, D., Conway, J., Combes, J., Hatlie, M., Leape, L., . . . Walton, M. (2008). What Exactly Is Patient Safety? In K. Henriksen, J. B. Battles, M. A. Keyes & M. L. Grady (Eds.), *Advances in Patient Safety: New Directions and Alternative Approaches (Vol. 1: Assessment)*. Rockville (MD).

Falcone, R. A., Jr., Daugherty, M., Schweer, L., Patterson, M., Brown, R. L., & Garcia, V. F. (2008). Multidisciplinary pediatric trauma team training using high-fidelity trauma simulation. *J Pediatr Surg, 43*(6), 1065-1071. doi: 10.1016/j.jpedsurg.2008.02.033

Fernandez, R., Vozenilek, J. A., Hegarty, C. B., Motola, I., Reznek, M., Phrampus, P. E., & Kozlowski, S. W. (2008). Developing expert medical teams: toward an evidence-based approach. *Acad Emerg Med, 15*(11), 1025-1036. doi: 10.1111/j.1553-2712.2008.00232.x

Figueroa, M. I., Sepanski, R., Goldberg, S. P., & Shah, S. (2013). Improving teamwork, confidence, and collaboration among members of a pediatric cardiovascular intensive care unit multidisciplinary team using simulation-based team training. *Pediatr Cardiol, 34*(3), 612-619. doi: 10.1007/s00246-012-0506-2

Firman, M. (2008). Structured interview. In Lisa M Given (Ed.), *The SAGE encyopedia of qualitative research methods* (pp. 838-839). Thousand Oaks, CA: SAGE Publications inc.

Firmin, M. (2008). Unstructured interview. In Lisa M Given (Ed.), *the SAGE encyclopedia of qualitative research methods*. Thousand Oaks CA: SAGE publications Inc.

Fletcher, G., Flin, R., McGeorge, P., Glavin, R., Maran, N., & Patey, R. (2003). Anaesthetists' Non-Technical Skills (ANTS): evaluation of a behavioural marker system. [Evaluation Studies Research Support, Non-U.S. Gov't]. *Br J Anaesth, 90*(5), 580-588.

Flores, G., & Weinstock, D. J. (1996). The preparedness of pediatricians for emergencies in the office. What is broken, should we care, and how can we fix it? [Research Support, Non-U.S. Gov't]. *Arch Pediatr Adolesc Med, 150*(3), 249-256.

Fuijkschot, J., Vernhout, B., Lemson, J., Draaisma, J. M., & Loeffen, J. L. (2015). Validation of a Paediatric Early Warning Score: first results and implications of usage. [Validation Studies]. *Eur J Pediatr, 174*(1), 15-21. doi: 10.1007/s00431-014-2357-8

Geis, G. L., Pio, B., Pendergrass, T. L., Moyer, M. R., & Patterson, M. D. (2011). Simulation to assess the safety of new healthcare teams and new facilities. *Simul Healthc, 6*(3), 125-133. doi: 10.1097/SIH.0b013e31820dff30

Gold, Raymond L. (1958). Roles in Sociological Field Observations. *Social Forces, 26*(3), 217-223.

Gordon, M., Darbyshire, D., & Baker, P. (2012). Non-technical skills training to enhance patient safety: a systematic review. [Review]. *Med Educ, 46*(11), 1042-1054. doi: 10.1111/j.1365-2923.2012.04343.x

Grant, D. J., & Marriage, S. C. (2012). Training using medical simulation. [Review]. *Arch Dis Child, 97*(3), 255-259. doi: 10.1136/archdischild-2011-300592

Grant, E. C., Grant, V. J., Bhanji, F., Duff, J. P., Cheng, A., & Lockyer, J. M. (2012). The development and assessment of an evaluation tool for pediatric resident competence in leading simulated pediatric resuscitations. [Research Support, Non-U.S. Gov't]. *Resuscitation, 83*(7), 887-893. doi: 10.1016/j.resuscitation.2012.01.015

Green, Bill (Ed.). (2009). *Understanding and Researching Professional Practice*. Rotterdam The Netherlands: Sense Publishers.

Gunn, A. J., Gunn, T. R., & Mitchell, E. A. (2000). Is changing the sleep environment enough? Current recommendations for SIDS. *Sleep Med Rev, 4*(5), 453-469. doi: 10.1053/smrv.2000.0119

Hammick, M., Freeth, D., Koppel, I., Reeves, S., & Barr, H. (2007). A best evidence systematic review of interprofessional education: BEME Guide no. 9. [Review]. *Med Teach, 29*(8), 735-751. doi: 10.1080/01421590701682576

Herlitz, J., Bang, A., Alsen, B., & Aune, S. (2002). Characteristics and outcome among patients suffering from in hospital cardiac arrest in relation to the interval between collapse and start of CPR. *Resuscitation, 53*(1), 21-27.

Higgs, J., & McAllister, L. (2007). Educating clinical educators: using a model of the experience of being a clinical educator. *Med Teach, 29*(2-3), e51-57. doi: 10.1080/01421590601046088

Hogan, H., Healey, F., Neale, G., Thomson, R., Vincent, C., & Black, N. (2012). Preventable deaths due to problems in care in English acute hospitals: a retrospective case record review study. [Research Support, N.I.H., Extramural]. *BMJ Qual Saf, 21*(9), 737-745. doi: 10.1136/bmjqs-2011-001159

Holcomb, J. B., Dumire, R. D., Crommett, J. W., Stamateris, C. E., Fagert, M. A., Cleveland, J. A., . . . Mattox, K. L. (2002). Evaluation of trauma team performance using an advanced human patient simulator for resuscitation training. [Evaluation Studies]. *J Trauma, 52*(6), 1078-1085; discussion 1085-1076.

Howard, S. K., Gaba, D. M., Fish, K. J., Yang, G., & Sarnquist, F. H. (1992). Anesthesia crisis resource management training: teaching anesthesiologists to handle critical incidents. [Research Support, Non-U.S. Gov't Research Support, U.S. Gov't, Non-P.H.S.]. *Aviat Space Environ Med, 63*(9), 763-770.

Hunt, E. A., Duval-Arnould, J. M., Nelson-McMillan, K. L., Bradshaw, J. H., Diener-West, M., Perretta, J. S., & Shilkofski, N. A. (2014). Pediatric resident resuscitation skills improve after "rapid cycle deliberate practice" training. [Research Support, N.I.H., Extramural Research Support, Non-U.S. Gov't]. *Resuscitation, 85*(7), 945-951. doi: 10.1016/j.resuscitation.2014.02.025

Hunt, E. A., Heine, M., Hohenhaus, S. M., Luo, X., & Frush, K. S. (2007). Simulated pediatric trauma team management: assessment of an educational intervention. [Multicenter Study Research Support, U.S. Gov't, P.H.S.]. *Pediatr Emerg Care, 23*(11), 796-804. doi: 10.1097/PEC.0b013e31815a0653

Hunt, E. A., Hohenhaus, S. M., Luo, X., & Frush, K. S. (2006). Simulation of pediatric trauma stabilization in 35 North Carolina emergency departments: identification of targets for performance improvement. [Research Support, U.S. Gov't, P.H.S.]. *Pediatrics, 117*(3), 641-648. doi: 10.1542/peds.2004-2702

Hunt, E. A., Walker, A. R., Shaffner, D. H., Miller, M. R., & Pronovost, P. J. (2008). Simulation of in-hospital pediatric medical emergencies and cardiopulmonary arrests: highlighting the importance of the first 5 minutes. [Research Support, Non-U.S. Gov't]. *Pediatrics, 121*(1), e34-43. doi: 10.1542/peds.2007-0029

Hunziker, S., Johansson, A. C., Tschan, F., Semmer, N. K., Rock, L., Howell, M. D., & Marsch, S. (2011). Teamwork and leadership in cardiopulmonary resuscitation. [Research Support, Non-U.S. Gov't Review]. *J Am Coll Cardiol, 57*(24), 2381-2388. doi: 10.1016/j.jacc.2011.03.017

Improvement, Institute of Healthcare. (1999). To Err is Human: Institute of Healthcare Improvement.

J-J Rethans, J J Norcini, M Baro´n-Maldonado, D Blackmore, B C Jolly, T LaDuca, S Lew,, & Southgate, G G Page & L H. (2002). The relationship between competence and performance: implications for assessing practice performance. *Medical Education Blackwell Science, 36*, 901-909.

Jabbour, M., Osmond, M. H., & Klassen, T. P. (1996). Life support courses: are they effective? [Review]. *Ann Emerg Med, 28*(6), 690-698.

Jarvis, Peter. (2003). *Adult and Continuing Education*. London and New York: Routledge / Falmer.

Jarvis, Peter. (2005). *Towards a Comprehensive Theory of Human learning*. New York: Routledge Taylor and Francis Group.

Jewkes, F., & Phillips, B. (2003). Resuscitation training of paediatricians. *Arch Dis Child, 88*(2), 118-121.

Joy Higgs, Anne Croker, Diane Tasker, Jill Hummel and Narelle Paton (Ed.). (2014). *Health Practice Relationships*. Rotterdam, The Netherlands: Sense Publishers.

Kahneman, Daniel. (2011). *Thinking Fast Thinking Slow*. New York: Farrar, Straus and Giroux.

Katznelson, J. H., Mills, W. A., Forsythe, C. S., Shaikh, S., & Tolleson-Rinehart, S. (2014). Project CAPE: a high-fidelity, in situ simulation program to increase Critical Access Hospital Emergency Department provider comfort with seriously ill pediatric patients. [Research Support, Non-U.S. Gov't]. *Pediatr Emerg Care, 30*(6), 397-402. doi: 10.1097/PEC.0000000000000146

Kennedy, Ian. (2001). Learning from Bristol. In Secretary of State for Health (Ed.). London UK.

Kennedy, J. L., Jones, S. M., Porter, N., White, M. L., Gephardt, G., Hill, T., . . . Thompson, T. M. (2013). High-fidelity hybrid simulation of allergic emergencies demonstrates improved preparedness for office emergencies in pediatric allergy clinics. [Research Support, Non-U.S. Gov't]. *J Allergy Clin Immunol Pract, 1*(6), 608-617 e601-614. doi: 10.1016/j.jaip.2013.07.006

Kilner, E., & Sheppard, L. A. (2010). The role of teamwork and communication in the emergency department: a systematic review. [Review]. *Int Emerg Nurs, 18*(3), 127-137. doi: 10.1016/j.ienj.2009.05.006

King, H. B., Battles, J., Baker, D. P., Alonso, A., Salas, E., Webster, J., . . . Salisbury, M. (2008). TeamSTEPPS: Team Strategies and Tools to Enhance Performance and Patient Safety. In K. Henriksen, J. B. Battles, M. A. Keyes & M. L. Grady (Eds.), *Advances in Patient Safety: New Directions and Alternative Approaches (Vol. 3: Performance and Tools)*. Rockville (MD).

Kirkpatrick, Donald L, & Kirkpatrick, James D. (2005). Transferring Learning to Behaviour Vol. Berrett-Koehler Publishers Inc.

Kirkpatrick, Donald L, & Kirkpatrick, James D. (2007). Implementing the Four Levels

Knowles, Malcolm S, & III, Ellwood F Holton. (2012). *The Adult Learner*: Routledge Taylor and Francis Group.

Kotsakis, A., Mercer, K., Mohseni-Bod, H., Gaiteiro, R., & Agbeko, R. (2015). The development and implementation of an inter-professional simulation based pediatric acute care curriculum for ward health care providers. *J Interprof Care, 29*(4), 392-394. doi: 10.3109/13561820.2014.984018

Kurosawa, H., Ikeyama, T., Achuff, P., Perkel, M., Watson, C., Monachino, A., . . . Nishisaki, A. (2014). A randomized, controlled trial of in situ pediatric advanced life support recertification ("pediatric advanced life support reconstructed") compared with standard pediatric advanced life support recertification for ICU frontline providers*. [Comparative Study Randomized Controlled Trial
Research Support, U.S. Gov't, P.H.S.]. *Crit Care Med, 42*(3), 610-618. doi: 10.1097/CCM.0000000000000024

Lage, Maureen J , Platt, Glenn J, & Treglia, Michael. (2000). Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment. *The Journal of Economic Education, 31*(1), 30-43.

Leonard, M., Graham, S., & Bonacum, D. (2004). The human factor: the critical importance of effective teamwork and communication in providing safe care. *Qual Saf Health Care, 13 Suppl 1*, i85-90. doi: 10.1136/qhc.13.suppl_1.i85

Li, Y., & Thimbleby, H. (2014). Hot cheese: a processed Swiss cheese model. [Research Support, Non-U.S. Gov't]. *J R Coll Physicians Edinb, 44*(2), 116-121. doi: 10.4997/JRCPE.2014.205

Lopreiato, J. O. (Ed.), Downing, D.,, Gammon, W., Lioce, L., Sittner, B.,, Slot, V., Spain, A. E. (Associate Eds.),, Concepts, and the Terminology &, & Group., Working. (2016). Healthcare Simulation DictionaryTM. Retrieved from

Manser, T. (2009). Teamwork and patient safety in dynamic domains of healthcare: a review of the literature. [Review]. *Acta Anaesthesiol Scand, 53*(2), 143-151. doi: 10.1111/j.1399-6576.2008.01717.x

Marteau, T. M., Wynne, G., Kaye, W., & Evans, T. R. (1990). Resuscitation: experience without feedback increases confidence but not skill. *BMJ, 300*(6728), 849-850.

Matlow, A. G., Baker, G. R., Flintoft, V., Cochrane, D., Coffey, M., Cohen, E., . . . Nijssen-Jordan, C. (2012). Adverse events among children in Canadian hospitals: the Canadian Paediatric Adverse Events Study. [Research Support, Non-U.S. Gov't]. *CMAJ, 184*(13), E709-718. doi: 10.1503/cmaj.112153

McCulloch, P., Rathbone, J., & Catchpole, K. (2011). Interventions to improve teamwork and communications among healthcare staff. [Research Support, Non-U.S. Gov't Review]. *Br J Surg, 98*(4), 469-479. doi: 10.1002/bjs.7434

McKay, A., Walker, S. T., Brett, S. J., Vincent, C., & Sevdalis, N. (2012). Team performance in resuscitation teams: comparison and critique of two recently developed scoring tools. [Comparative Study Research Support, Non-U.S. Gov't]. *Resuscitation, 83*(12), 1478-1483. doi: 10.1016/j.resuscitation.2012.04.015

Merriam, S B. (1998). Qualitative research and case study applications in education.

Messmer, P. R. (2008). Enhancing nurse-physician collaboration using pediatric simulation. [Evaluation Studies Research Support, Non-U.S. Gov't]. *J Contin Educ Nurs, 39*(7), 319-327.

Michaelsen, Larry K, Parmelee, Dean X, McMahon, Kathryn K, & Levine, Ruth E (Eds.). (2008). *Team-Based Learning for Health Professions Education*. Sterlng, Virginia: Stlyus Publishing LLC.

Mikrogianakis, A., Osmond, M. H., Nuth, J. E., Shephard, A., Gaboury, I., & Jabbour, M. (2008). Evaluation of a multidisciplinary pediatric mock trauma code educational initiative: a pilot study. [Evaluation Studies Research Support, Non-U.S. Gov't]. *J Trauma, 64*(3), 761-767. doi: 10.1097/TA.0b013e3180341ff8

Miller, G. E. (1990). The assessment of clinical skills/competence/performance. *Acad Med, 65*(9 Suppl), S63-67.

Mishra, A., Catchpole, K., & McCulloch, P. (2009). The Oxford NOTECHS System: reliability and validity of a tool for measuring teamwork behaviour in the operating theatre. [Research Support, Non-U.S. Gov't Validation Studies]. *Qual Saf Health Care, 18*(2), 104-108. doi: 10.1136/qshc.2007.024760

Miyazaki, A., Sakaguchi, H., Ohuchi, H., Yasuda, K., Tsujii, N., Matsuoka, M., . . . Yamada, O. (2015). The clinical characteristics of sudden cardiac arrest in asymptomatic patients with congenital heart disease. *Heart Vessels, 30*(1), 70-80. doi: 10.1007/s00380-013-0444-9

Moler, F. W., Meert, K., Donaldson, A. E., Nadkarni, V., Brilli, R. J., Dalton, H. J., . . . Dean, J. M. (2009). In-hospital versus out-of-hospital pediatric cardiac arrest: a multicenter cohort study. [Multicenter Study Research Support, N.I.H., Extramural Research Support, U.S. Gov't, P.H.S.]. *Crit Care Med, 37*(7), 2259-2267. doi: 10.1097/CCM.0b013e3181a00a6a

Morey, J. C., Simon, R., Jay, G. D., Wears, R. L., Salisbury, M., Dukes, K. A., & Berns, S. D. (2002). Error reduction and performance improvement in the emergency department through formal teamwork training: evaluation results of the MedTeams project. [Multicenter Study Research Support, U.S. Gov't, Non-P.H.S.]. *Health Serv Res, 37*(6), 1553-1581.

Morse, W. H., & Skinner, B. F. (1958). Some factors involved in the stimulus control of operant behavior. *J Exp Anal Behav, 1*, 103-107. doi: 10.1901/jeab.1958.1-103

NET, PICA. (2009). National Report of The Paediatric Intensive Care Audit Network: Paediatric Intensive Care Audit Network.

Nishisaki, A., Donoghue, A. J., Colborn, S., Watson, C., Meyer, A., Brown, C. A., 3rd, . . . Nadkarni, V. M. (2010). Effect of just-in-time simulation training on tracheal intubation procedure safety in the pediatric intensive care unit. [Research Support, U.S. Gov't, P.H.S.]. *Anesthesiology, 113*(1), 214-223. doi: 10.1097/ALN.0b013e3181e19bf2

Nishisaki, A., Donoghue, A. J., Colborn, S., Watson, C., Meyer, A., Niles, D., . . . Boulet, J. R. (2012). Development of an instrument for a primary airway provider's performance with an ICU multidisciplinary team in pediatric respiratory failure using simulation. [Research Support, U.S. Gov't, P.H.S.]. *Respir Care, 57*(7), 1121-1128. doi: 10.4187/respcare.01472

Nwokorie, N., Svoboda, D., Rovito, D. K., & Krugman, S. D. (2012). Effect of focused debriefing on team communication skills. *Hosp Pediatr, 2*(4), 221-227.

O'Leary, F., McGarvey, K., Christoff, A., Major, J., Lockie, F., Chayen, G., . . . Wharton, S. (2014). Identifying incidents of suboptimal care during paediatric emergencies-an observational study utilising in situ and simulation centre scenarios. [Observational Study]. *Resuscitation, 85*(3), 431-436. doi: 10.1016/j.resuscitation.2013.12.001

Ottewill, M. (2003). The current approach to human error and blame in the NHS. [Comparative Study]. *Br J Nurs, 12*(15), 919-924. doi: 10.12968/bjon.2003.12.15.11419

Patterson, M. D., Geis, G. L., Falcone, R. A., LeMaster, T., & Wears, R. L. (2013). In situ simulation: detection of safety threats and teamwork training in a high risk emergency department. [Research Support, U.S. Gov't, P.H.S.]. *BMJ Qual Saf, 22*(6), 468-477. doi: 10.1136/bmjqs-2012-000942

Patterson, M. D., Geis, G. L., LeMaster, T., & Wears, R. L. (2013). Impact of multidisciplinary simulation-based training on patient safety in a paediatric emergency department. [Research Support, U.S. Gov't, P.H.S.]. *BMJ Qual Saf, 22*(5), 383-393. doi: 10.1136/bmjqs-2012-000951

Pavlov, I. P. (1928). *Lectures on conditioned reflexes. (Translated by W.H. Gantt)*. London: Allen and Unwin.

Pavlov, I. P. (1951). [Conditioned reflex]. *Feldsher Akush, 10*, 3-10; contd.

Perneger, T. V. (2005). The Swiss cheese model of safety incidents: are there holes in the metaphor? *BMC Health Serv Res, 5*, 71. doi: 10.1186/1472-6963-5-71

Randolph, A. G., Gonzales, C. A., Cortellini, L., & Yeh, T. S. (2004). Growth of pediatric intensive care units in the United States from 1995 to 2001. [Multicenter Study
Research Support, U.S. Gov't, P.H.S.]. *J Pediatr, 144*(6), 792-798. doi: 10.1016/j.jpeds.2004.03.019

Reason, J. (1990). The contribution of latent human failures to the breakdown of complex systems. *Philos Trans R Soc Lond B Biol Sci, 327*(1241), 475-484.

Reason, J. (1995). Understanding adverse events: human factors. *Qual Health Care, 4*(2), 80-89.

Reason, J. (2000). Human error: models and management. *BMJ, 320*(7237), 768-770.

Reason, James. (2008). *The Human Contribution*. Farnham Surrey: Ashgate.

Reid, J., Stone, K., Brown, J., Caglar, D., Kobayashi, A., Lewis-Newby, M., . . . Quan, L. (2012). The Simulation Team Assessment Tool (STAT): development, reliability and validation. [Research Support, Non-U.S. Gov't

Validation Studies]. *Resuscitation, 83*(7), 879-886. doi: 10.1016/j.resuscitation.2011.12.012

Rosen, M. A., Hunt, E. A., Pronovost, P. J., Federowicz, M. A., & Weaver, S. J. (2012). In situ simulation in continuing education for the health care professions: a systematic review. [Review]. *J Contin Educ Health Prof, 32*(4), 243-254. doi: 10.1002/chp.21152

Rudolph, J. W., Simon, R., Dufresne, R. L., & Raemer, D. B. (2006). There's no such thing as "nonjudgmental" debriefing: a theory and method for debriefing with good judgment. [Research Support, Non-U.S. Gov't

Research Support, U.S. Gov't, Non-P.H.S.]. *Simul Healthc, 1*(1), 49-55.

Rudolph, J. W., Simon, R., Rivard, P., Dufresne, R. L., & Raemer, D. B. (2007). Debriefing with good judgment: combining rigorous feedback with genuine inquiry. [Review]. *Anesthesiol Clin, 25*(2), 361-376. doi: 10.1016/j.anclin.2007.03.007

Salas, E., DiazGranados, D., Klein, C., Burke, C. S., Stagl, K. C., Goodwin, G. F., & Halpin, S. M. (2008). Does team training improve team performance? A meta-analysis. [Comparative Study Meta-Analysis Research Support, U.S. Gov't, Non-P.H.S. Review]. *Hum Factors, 50*(6), 903-933.

Salas, E., Wilson, K. A., Murphy, C. E., King, H., & Salisbury, M. (2008). Communicating, coordinating, and cooperating when lives depend on it: tips for teamwork. *Jt Comm J Qual Patient Saf, 34*(6), 333-341.

Salas, Eduardo, Sims, Dana E., & Burk, C. Shawn. (2005). Is there a 'Big Five' in Teamwork. *Small Group Research, 36*(5), 555-599.

Scalese, R. J., Obeso, V. T., & Issenberg, S. B. (2008). Simulation technology for skills training and competency assessment in medical education. [Review]. *J Gen Intern Med, 23 Suppl 1*, 46-49. doi: 10.1007/s11606-007-0283-4

Schon, Donald A. (1083). *The Reflective Practitioner: How Professionals Think in Action*. United States of America: Basic Books.

Sexton, J. B., Thomas, E. J., & Helmreich, R. L. (2000). Error, stress, and teamwork in medicine and aviation: cross sectional surveys. [Comparative Study Research Support, Non-U.S. Gov't]. *BMJ, 320*(7237), 745-749.

Siassakos, D., Fox, R., Crofts, J. F., Hunt, L. P., Winter, C., & Draycott, T. J. (2011). The management of a simulated emergency: better teamwork, better performance. [Research Support, Non-U.S. Gov't]. *Resuscitation, 82*(2), 203-206. doi: 10.1016/j.resuscitation.2010.10.029

Skinner, B. F. (1938). *The Behavior of organisms: An experimental analysis.* . New York: Appleton-Century.

Sockeel, P., Chatelain, E., Massoure, M. P., David, P., Chapellier, X., & Buffat, S. (2009). [Surgeons can learn from pilots: human factors in surgery]. *J Chir (Paris), 146*(3), 250-255. doi: 10.1016/j.jchir.2009.06.011

Soop, M., Fryksmark, U., Koster, M., & Haglund, B. (2009). The incidence of adverse events in Swedish hospitals: a retrospective medical record review study. [Research Support, Non-U.S. Gov't]. *Int J Qual Health Care, 21*(4), 285-291. doi: 10.1093/intqhc/mzp025

Spencer, F. C. (2000). Human error in hospitals and industrial accidents: current concepts. [Review]. *J Am Coll Surg, 191*(4), 410-418.

Stocker, M., Allen, M., Pool, N., De Costa, K., Combes, J., West, N., & Burmester, M. (2012). Impact of an embedded simulation team training programme in a paediatric intensive care unit: a prospective, single-centre, longitudinal study. [Evaluation Studies]. *Intensive Care Med, 38*(1), 99-104. doi: 10.1007/s00134-011-2371-5

Svavarsdottir, Hildigunnur, & Brattebo, Guttorm (2013). Team training - The BEST approach to continuing education in resuscitation. *Trends in Anaesthesia and Critical Care*(3), 140-145.

Tavakol, M., & Sandars, J. (2014a). Quantitative and qualitative methods in medical education research: AMEE Guide No 90: Part I. *Med Teach, 36*(9), 746-756. doi: 10.3109/0142159X.2014.915298

Tavakol, M., & Sandars, J. (2014b). Quantitative and qualitative methods in medical education research: AMEE Guide No 90: Part II. *Med Teach, 36*(10), 838-848. doi: 10.3109/0142159X.2014.915297

Theilen, U., Leonard, P., Jones, P., Ardill, R., Weitz, J., Agrawal, D., & Simpson, D. (2013). Regular in situ simulation training of paediatric medical emergency team improves hospital response to deteriorating patients. *Resuscitation, 84*(2), 218-222. doi: 10.1016/j.resuscitation.2012.06.027

Thorndike, E. L. (1905). *The elements of psychology.* New Tork: A. G. Seiler.

Tibballs, J., Kinney, S., Duke, T., Oakley, E., & Hennessy, M. (2005). Reduction of paediatric in-patient cardiac arrest and death with a medical emergency team: preliminary results. *Arch Dis Child, 90*(11), 1148-1152. doi: 10.1136/adc.2004.069401

Toback, S. L., Fiedor, M., Kilpela, B., & Reis, E. C. (2006). Impact of a pediatric primary care office-based mock code program on physician and staff confidence to perform life-saving skills. [Clinical Trial

Research Support, Non-U.S. Gov't]. *Pediatr Emerg Care, 22*(6), 415-422. doi: 10.1097/01.pec.0000221342.11626.12

Underwood, P., & Waterson, P. (2014). Systems thinking, the Swiss Cheese Model and accident analysis: a comparative systemic analysis of the Grayrigg train derailment using the ATSB, AcciMap and STAMP models. [Comparative Study]. *Accid Anal Prev, 68*, 75-94. doi: 10.1016/j.aap.2013.07.027

van der Starre, C., van Dijk, M., & Tibboel, D. (2012). Real-time registration of adverse events in Dutch hospitalized children in general pediatric units: first experiences. [Evaluation Studies Research Support, Non-U.S. Gov't]. *Eur J Pediatr, 171*(3), 553-558. doi: 10.1007/s00431-011-1608-1

Vincent, C., Neale, G., & Woloshynowych, M. (2001). Adverse events in British hospitals: preliminary retrospective record review. [Research Support, Non-U.S. Gov't]. *BMJ, 322*(7285), 517-519.

Volk, M. S., Ward, J., Irias, N., Navedo, A., Pollart, J., & Weinstock, P. H. (2011). Using medical simulation to teach crisis resource management and decision-making skills to otolaryngology housestaff. [Research Support, Non-U.S. Gov't]. *Otolaryngol Head Neck Surg, 145*(1), 35-42. doi: 10.1177/0194599811400833

Waisman, Y., Amir, L., & Mimouni, M. (1997). PALS course improves preparedness for pediatric emergencies. [Comment Letter]. *Arch Pediatr Adolesc Med, 151*(1), 106-107.

Walker, S., Brett, S., McKay, A., Lambden, S., Vincent, C., & Sevdalis, N. (2011). Observational Skill-based Clinical Assessment tool for Resuscitation (OSCAR): development and validation. [Comparative Study Research Support, Non-U.S. Gov't Validation Studies]. *Resuscitation, 82*(7), 835-844. doi: 10.1016/j.resuscitation.2011.03.009

Wang, E. E., Quinones, J., Fitch, M. T., Dooley-Hash, S., Griswold-Theodorson, S., Medzon, R., . . . Clay, L. (2008). Developing technical expertise in emergency medicine--the role of simulation in procedural skill acquisition. *Acad Emerg Med, 15*(11), 1046-1057. doi: 10.1111/j.1553-2712.2008.00218.x

Weick, K. E. (2003). Sense and reliability. A conversation with celebrated psychologist Karl E. Weick. Interview by Diane L. Coutu. [Interview]. *Harv Bus Rev, 81*(4), 84-90, 123.

Weinstock, P. (2012). Weathering the perfect storm: a deeper look at simulation applied to pediatric critical care. [Comment Editorial]. *Pediatr Crit Care Med, 13*(2), 226-227. doi: 10.1097/PCC.0b013e318223126b

Weinstock, P. H., Kappus, L. J., Garden, A., & Burns, J. P. (2009). Simulation at the point of care: reduced-cost, in situ training via a mobile cart. [Research Support, Non-U.S. Gov't]. *Pediatr Crit Care Med, 10*(2), 176-181. doi: 10.1097/PCC.0b013e3181956c6f

Weinstock, P. H., Kappus, L. J., Kleinman, M. E., Grenier, B., Hickey, P., & Burns, J. P. (2005). Toward a new paradigm in hospital-based pediatric education: the development of an onsite simulator program. [Comment]. *Pediatr Crit Care Med, 6*(6), 635-641.

Weller, J., Boyd, M., & Cumin, D. (2014). Teams, tribes and patient safety: overcoming barriers to effective teamwork in healthcare. [Review]. *Postgrad Med J, 90*(1061), 149-154. doi: 10.1136/postgradmedj-2012-131168

Weller, J. M., Cumin, D., Civil, I. D., Torrie, J., Garden, A., MacCormick, A. D., . . . Merry, A. F. (2016). Improved scores for observed teamwork in the clinical environment following a multidisciplinary operating room simulation intervention. *N Z Med J, 129*(1439), 59-67.

Weller, J., Shulruf, B., Torrie, J., Frengley, R., Boyd, M., Paul, A., . . . Dzendrowskyj, P. (2013). Validation of a measurement tool for self-assessment of teamwork in intensive care. [Research Support, Non-U.S. Gov't Validation Studies]. *Br J Anaesth, 111*(3), 460-467. doi: 10.1093/bja/aet060

Wheeler, D. S., Geis, G., Mack, E. H., LeMaster, T., & Patterson, M. D. (2013). High-reliability emergency response teams in the hospital: improving quality and safety using in situ simulation training. [Research Support, U.S. Gov't, P.H.S.]. *BMJ Qual Saf, 22*(6), 507-514. doi: 10.1136/bmjqs-2012-000931

Xyrichis, A., & Ream, E. (2008). Teamwork: a concept analysis. [Review]. *J Adv Nurs, 61*(2), 232-241. doi: 10.1111/j.1365-2648.2007.04496.x

Zeltser, M. V., & Nash, D. B. (2010). Approaching the evidence basis for aviation-derived teamwork training in medicine. *Am J Med Qual, 25*(1), 13-23. doi: 10.1177/1062860609345664

Zimmermann, K., Holzinger, I. B., Ganassi, L., Esslinger, P., Pilgrim, S., Allen, M., . . . Stocker, M. (2015). Inter-professional in-situ simulated team and resuscitation training for patient safety: Description and impact of a programmatic approach. *BMC Med Educ, 15*, 189. doi: 10.1186/s12909-015-0472-5

Appendix

Appendix i:

Summary of *all* Papers Reviewed (Including Editorials, Reviews and Original Research)

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Review Articles					
Resuscitation training of paediatricians 2003	F Jewkes B Phillips	Review of Resuscitation Training	N/A	N/A	Describe need for training and history of resuscitation courses • Review importance of faculty having instructor training • Look at evidence for resuscitation courses • Discussed area of skill retention
New aspects on critical care medicine training 2004	Ake Grenvik John J SchaeferMichael A DeVita Paul Rogers	Review Article	N/A	N/A	Three fundamental changes in clinical education: • Evidenced based medicine • Patient Safety • Use of simulation • Outlines advantages of simulation training
The patient died, but we can try again: simulation in pediatric critical care training 2005	Rainer Gedeit	Editorial	N/A	N/A	Refers to paper describing development of Boston Children's Hospital Simulation Centers. • Financial • Proximity to clinical space • Volunteer Faculty • Development of validated clinical scenarios Multidisciplinary educators and learners

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Emergency and critical care pediatrics: use of medical simulation for training in acute pediatric emergencies 2006	Walter J Eppich Mark D Adler William C McGaghie	Review Article	N/A	N/A	• Simulation as a training strategy • Concept of deliberate practice • Key features of simulation including integration into the curricula
Simulation in paediatrics: An educational revolution 2007	Adam Cheng Jonathon Duff Estee Grant Niranjan Kissoon Vincent J Grant	Authors Review of simulation in paediatrics	N/A	N/A	• Definition of Simulation • How realism is achieved • Benefits of Simulation
Simulator-based training in paediatric anaesthesia and emergency medicine – Thrills, skills and attitudes 2007	C Eich A Timmermann S G Russo E A Nickel J McFadzean D Rowney S K W Schwartz	Review - Editorial	N/A	N/A	• Effective application of non technical skills requires non technical skills • Simulation-based training can enhance • Simulator Training of Clinical Teams becomes increasingly important
Bridging the knowledge-resuscitation gap for children: Still a long way to go 2007	Ran D Country Kendall Ho Robert Peterson Niranjan Kissoon	Review Article	N/A	N/A	Discussion of evidence for translating knowledge to practice including: • Interactive workshops • Outreach visits with opinion leaders • Resuscitation courses • Mock codes • Discussion of stress and uncertainty in acute events

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Team Training: implications for emergency and critical care pediatrics 2008	Walter J Eppich Melissa Brannen Elizabeth Hunt	Review Article	N/A	N/A	• Team and Teamwork • Teams and communication • Learning from other Industries • Team Training in Emergency Medicine • Team Training in Pediatrics • Multidisciplinary Teams
Teamwork in pediatric heart care 2009	R Krishna	Review Article	N/A	N/A	Key requirements of a cohesive team: • Level of skill and experience • Mutual trust and respect • Understanding roles and personalities • Communication • Collective sense of responsibility • Review of performance
The use of simulation for pediatric training and assessment 2009	Eric R Weinberg Marc A Auerbach Nikhil B Shah	Authors review of simulation in paediatric training and assessment	N/A	N/A	Evidenced based review for role of simulation in: • Resuscitation • Trauma management • Airway management • Procedural Skills • CRM • Disaster / mass casualty training

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Simulation-based crisis resource management training for pediatric critical care medicine: A review for instructors 2011	Adam Cheng Elaine Gilfoyle Walter Eppich	Review Article	N/A	N/A	• Defining a team • Principles of Crisis resource Management • Applicability to Pediatric Resuscitation • Simulation based education for CRM training • Debriefing Strategies • Assessment of CRM performance
Training using medical simulation 2012	David J Grant Stephen C Marriage	Authors Review of Medical Simulation in paediatric practice and description of Bristol Paediatric Simulation Program	Bristol Paediatric Simulation Program: • Matching simulation to formal RCPCH training requirements • Level 1 Trainees: Specific acute competencies • Level 2 Trainees - CRM	Standard Evaluation using Likert Scale	Discussed areas such as: • Development of Medical simulation • Effectiveness of Medical Simulation • Educational Theory • Matching Simulation to formal training requirements • The future
Weathering the perfect storm: A deeper look at simulation applied to pediatric critical care 2012	Peter Weinstock	Editorial	N/A	N/A	A refocusing on structured process for each pedagogical element • Objectives • Scenario design • Signal to noise ratio Program sustainability

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Team training – The BEST approach to continuing education in resuscitation 2013 (19)	Hildigunnur Svavarsdottir Guttorm Brattebo	Descriptive Review of BEST simulation program in Norway and Iceland	Each course is 1 day long. 3 hours lectures and discussions 4 hours practical with 20 min simulation then debriefing and then a second simulation		Description of BEST simulation program which stands for 'Better and Systematic Team Training. This is: • On site • Interprofessional • CRM training Also discussion of leadership
Optimisation of simulated team training through the application of learning theories: a debate for a conceptual framework 2014	Martin Stocker Margarita Burmester Meredith Allen	Review of learning theories and their application to simulation	N/A	N/A	Organised under specific debates: • Debate 1: Single versus repeat exposure • Debate2:Simple experience versus experience of failure • Debate 3:Individual reflection versus critical reflection in the group • Debate 4: Improvised versus real teams • Debate 5: Simulation centre versus in-situ simulation
The role of simulation in teaching pediatric resuscitation: current perspectives 2015	Yiqun Lin Adam Cheng	Literature Review of simulation in resuscitation training	N/A	N/A	Neonatal Resuscitation • Variable results • One study showed reduction in HIE Paediatric advanced life support • Simulation incorporated into curricula • Potential benefits CRM • Increasing evidence of effectiveness

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Simulation-based Medical Education: Time for a Pedagogical Shift 2015	Kaarthigeyan Kalaniti Douglas M Campbell	Authors Review of the role of Simulation in Medical Education	N/A	N/A	Discussed areas such as: • Evolution of simulation • Educational methodologies • Role of stress in simulation • Fidelity (authenticity) in Simulation • Stages of Simulation • Competency assessment • Simulation Facility Limitations
Original Articles					
Pediatric Resuscitation: Development of a Mock Code Program and Evaluation Tool 1995 (28)	Dorothy Bishop-Kurylo Mathew Masiello	Descriptive Study: Pilot of Mock Codes	Mock Codes conducted twice a month	Evaluated using: Paediatric Mock Arrest Checklist Evaluation (PMACE)	• Scoring using PMACE ranged from 60-94% (reflecting % of skills met during mock code). • Increased confidence of staff • Identification of latent errors such as delay in arrival of defibrillator
Toward a new paradigm in hospital-based pediatric education: The development of an onsite simulator program 2005 (10)	Peter H Weinstock Liana J Kappus Monica E Kleinman Barry Grenier Patricia Hickey Jeffrey P Burns	Descriptive Study: Establishment of an In Situ Program	Development of Simulation Center for on site Pediatric Education (SCOPE) at Boston's Children's Hospital		7 Departments 129 individuals Description of: • Simulation room located close to PICU. • Set up costs • Operational costs • Time utilization • Usage

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Evaluation of a Multidisciplinary Pediatric Mock Trauma Code Educational Initiative: A Pilot Study 2006 (6)	Angelo Mikrogianakis Martin H Osmond Janet E Nuh Allyson Shepherd Isabelle Gaboury Mona Jabbour	Quasi Experimental: Orientation Simulation Intervention with follow up Regular Mock Codes	1 hour planned session consisting of trauma code and debriefing and second code	• Videos of pre and post intervention mock codes • Scenarios scored by two observers blinded • Scoring derived from Holcomb et al	37 medical trainees completed pre and post questionnaire • Residents reported a lower score of knowledge of where to find equipment ***after*** intervention Video analysis showed no difference in team functioning
Impact of a Pediatric Primary Care Office-based Mock Code Program on Physician and Staff Confidence to Perform Life-saving Skills 2006 (4)	Seth L Toback Melinda Fiedor Brian Kilpela Evelyn Cohen Reis	Quasi experimental design: Surveys pre and post intervention	11 Group Practices Contacted 1 hour lecture and equipment demonstration 1 hour simulated code	No Tools Pre and Post intervention survey	164 physicians and Staff 112/164 (68%) completed pre intervention survey 140/164 completed educational session and post intervention survey • Increased comfort and confidence • Greater standardization of survey responses post intervention
Simulated Pediatric Trauma Team Management 2007 (5)	Elizabeth A Hunt Margaret Heine Susan M Hohenhaus Xuemei Luo Karen S Frush	Quasi Experimental: Educational intervention including Simulation	18 ED Sites Unannounced simulated pediatric trauma resusc with debriefing (45-60 minutes). Distribution of manual / equip / Broselow-Luten tape	• Clinical assessment tool • Contained list of 44 critical tasks categorized into • Primary survey • Secondary survey • Procedural	Improvement in resuscitation ‘tasks’ by ED Team and increased number of tasks completed following intervention

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Simulation of In – Hospital Pediatric Emergencies and Cardiopulmonary Arrests: Highlighting the Importance of the 5 minutes 2007 (8)	Elizabeth A Hunt Allen R Walker Donald H Shaffner Marlene R Miller Peter J Provonost	Prospective Observational Study of Mock Codes	Data collected on group performance within simulated codes held in situ.	• Measurements included time to specific resuscitation maneuvers • Taxonomy of errors also created	34 Mock Codes during 40 months • In 25% of scenarios first responders took > 5 minutes to initiate ventilation. • All of the codes had at least one technical resuscitation error • Leaders often performing tasks rather than leading
Multidisciplinary pediatric trauma team training using high fidelity trauma simulation 2008 (18)	Richard A Falcone Jr Margot Daugherty Lynn Schweer Mary Patterson Rebeccah L Brown Victor F Garcia	Quasi Experimental: Educational intervention including Simulation	All trauma education activities had an emphasis on communication and team function and 2 hour trauma simulation sessions were developed	• Videos from simulated scenarios • Scored by two reviewers blinded to whether the videos were from an early or late group • Tool based on scoring sheet previously published (Holcomb et al)	46 simulation sessions were held in the 12 month period. 160 individuals participated and trauma care nurses participated in nearly 3 sessions each. Improvement in technical skills over time
Enhancing Nurse-Physician Collaboration Using Pediatric Simulation 2008 (33)	Patricia R Messmer	Descriptive study.	Observation of nurses and pediatric residents during simulated scenarios as part of the code team	• Scored on Kramer and Schmalenberg Nurse Physician Scale (KSNPS)	Nurses and physicians self reported high level of collaboration Analysis of videotapes showed that collaboration improved over time.

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Simulation at the point of care: Reduced-cost, in situ training via a mobile cart 2009 (25)	Peter H Weinstock Liana J Kappus Alexander Garden Jeffrey P Burns	Descriptive study	Construction of a self-contained mobile simulation cart with all the equipment necessary to facilitate in situ simulation	N/A	Cost of $ (Am) 8054 57 courses to 425 interdisciplinary participants
Effect of Just-in-time Simulation Training on Tracheal Intubation Procedure Safety in the Pediatric Intensive Care Unit 2010 (22)	Akira Nishisaki Aaron J Donaghue Shawn Colborn Christine Watson Andrew Meyer Dana Niles Et al	Quasi Experimental: Prospective Skill Simulation Interventional Study	Multidisciplinary simulation-based tracheal intubation training: Skill based 10 minutes Standardized Multidisciplinary team training with debriefing for 20 minutes	Observation for first attempt success at intubation Details of tracheal intubation associated events also collected	202 simulation events between June 2007 and August 2008 78 residents / 122 PICU nurses / 65 respiratory therapists • Increased resident participation in intubation • No significant improvement in tracheal intubation by residents or decrease in Tracheal Intubation Associated Events
Simulation- based training delivered pediatric directly to the pediatric cardiac intensive care unit engenders preparedness, comfort, and decreased anxiety among multidisciplinary teams 2010 (13)	Catherine K Allan Ravi R Thiagarajan Dorothy Beke Annette Imprescia Liana J Kappus Alexander Garden Gavin Hayes Peter C Laussen Emile Bacha P H Weinstock	Quasi Experimental: Simulation Based Crisis Resource Management Intervention	Multidisciplinary training program ran monthly of 4.5 hours which includes simulation (of real events) and debriefing	Pre course and post course questionnaires No Team based tools	182 providers in 27 courses over 33 months. Feedback from participants: • course useful • felt better prepared reduction in anxiety about codes • felt more confident in alerting leader if something to communicate

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Medical Simulation Topic Interests in a Pediatric Healthcare System 2010 (20)	Ellen S Deutsch Jason J Olivieri Jabayer Hassain Heather L Sobolewski	Web-Based Survey	1165 individuals surveyed within Delaware Valley (excluded trainees)	No simulation observation	173 responses from physicians (59%) 267 (33%) from nursing staff 50 (72%) respiratory therapists Highest level of interest by all 'Mock Codes"
Simulation to Assess the Safety of New Healthcare Teams and New Facilities 2011 (1)	Gary L Geis Brian Pio Tiffany L Pendergrass Michael R Moyer Mary D Patterson	Prospective Observational Pilot Study using Laboratory and In Situ Simulations	24 Laboratory and In Situ Simulations	• National Aeronautics and Space Administration Task Load index (NASA-TLX) completed by participants • Videos scored using Mayo High Perfomance Team Scale (MHPTS)	81 Healthcare providers • Laboratory Simulations identified issues around roles and scope • CRM Principles encouraged for In Situ Simulations • Medication Nurses felt frustrated with quantity of requests and time pressures • Identification of significant Facility resource issues
Simulation-based mock codes significantly correlate with improved pediatric patient cardiopulmonary arrest survival rates 2011 (23)	Pamela Andreatta Ernest Saxton Maureen Thompson Gail Annich	Longitudinal Mixed Methods: Quasi Experimental and Qualitative Thematic Analysis	Development of mock code curriculum	No Tools Senior resident provided self-assessment	• Contribution to improved cardiopulmonary arrest (CPA) outcomes.: • Improvement in CPA survival from 33% in 2005 to over 50% • Qualitative thematic analysis of learning: clinical techniques / team factors / supplies & resources / safety / management / diagnostic /

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Integrated In-Situ Simulation Using Redirected Faculty Educational Time to Minimise Costs: A Feasibility Study 2011 (9)	Aaron W Calhoun Megan C Boone Eleanor B Peterson Kimberly A Boland Vicki Montgomery	Descriptive Study: Establishment of an In Situ Program	Establishment of an In Situ simulation program based in the PICU		166 sessions between July 2008 and July 2010 244 staff per year • Start up costs • Operational costs • Development of CRM and communication simulations Faculty spent between 3% and 32% of their work hours facilitating the program
Impact of an embedded simulation team training programme in a paediatric intensive care unit: a prospective, single centre, longitudinal study 2011 (14)	Martin Stocker Meredith Allen Natasha Pool Kumi De Costa Julie Combes Neil West Margarita Burmester	Quasi Experimental: longitudinal study of Simulation Intervention	Multidisciplinary in situ simulation programme ran every 1-2 weeks of 2 hours which includes simulation and debriefing	No Teamwork Tools	219 providers between January 2009 and December 2010. 190 completed questionnaires (88.7%) Feedback from participants • 90% felt effective impact on non technical skills • 70% effective impact on technical skills
Impact of multidisciplinary simulation-based training on patient safety in a paediatric emergency department 2012 (15)	Mary D Patterson Gary L Geis Thomas LeMaster Robert L Wears	Quasi Experimental: Educational Intervention incorporating Simulation	Principles of CRM adapted to standardized simulation-based teamwork training for Paediatric ED Personnel over 2 days.	Participants completed a Safety Attitudes Questionnaire (SAQ) Assessment Scale Actual Simulated Scenarios and videos of actual clinical events analysed using Behavioural Markers Scale	289 Individuals between March 2005 and March 2008. Participants post intervention showed • Improved knowledge • Statistical improvement in attitudes to teamwork ED showed an associated reduction in patient safety events

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
In situ simulation: detection of safety threats and teamwork training in a high risk emergency department 2012 (7)	Mary D Patterson Gary Lee Geis Richard A Falcone Thomas LeMaster Robert L Wears	Prospective observational study aimed at describing latent errors	Implementation of 10 minutes in situ simulations 1-2 times per week with 10 minute debriefing	• Modified version of Anaesthetists Non-Technical Skills (ANTS)	218 individuals participated in at least 1 scenario 28% cancellation rate 73 latent system errors identified 37% of videos reviewed using ANTS – no change
Improving Teamwork, Confidence, and Collaboration Among Members of a Pediatric Cardiovascular Intensive Care Unit Multidisciplinary Team Using Simulation-Based Team Training 2013 (24)	Mayte I Figueroa Robert Sepanski Steven P Goldberg Samir Shah	Descriptive Study	Code simulation course for pediatric cardiac intensive care	• TeamSTEPPS principles in design of course • Checklist developed by course instructors to include critical performance criteria	37 participants • 5 Physicians • 23 nurses • 5 respiratory therapists • 4 others Improvement in confidence and skill / significant improvement in some aspects of teamwork
Regular in situ simulation training of paediatric Medical Emergency Team improves response to deteriorating patients 2012 (17)	U Theilen P Leonard P Jones R Ardill J Weitz D Agrawal D Simpson	Prospective cohort study of in patient admissions to PICU before and after intervention	Establishment of a multidisciplinary Medical Emergency Team with participation in simulated scenarios.	Audit of time from deterioration to first response No teamwork tools	Each training session was 2 hours 96 deteriorating patients with warning signs Reduction in time to review by MET to a median of 1.5 hours in the second year.
High-reliability emergency response teams in the hospital: improving quality and safety using in situ simulation training 2013 (16)	Derek S Wheeler Gary Geis Elizabeth H Mack Tom LeMaster Mary D Patterson	Prospective Single Centre Observational Study	Unannounced in situ simulations. 10 minute simulation and 10 minute debriefing	Standard debriefing – no teamwork tools	64 simulations between January 2008 and September 2009. 596 individuals. • 134 Latent System Threats identified

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Examining Pediatric Resuscitation Education Using Simulation and Scripted Debriefing 2013 (29)	EXPRESS Investigators (Cheng et al)	Prospective randomized factorial study design	2008-2011 453 participants recruited Four Study Arms Low realism scripted debriefing Low realism non scripted debriefing High realism Scripted debriefing High realism non scripted debriefing	• Use of multiple choice questions • Clinical Performance Tool (CAT) • Behavioural Assessment Tool (BAT)	443 completed pre and post MCQ 387 analysed for Clinical Performance Tool (CPT) and Behavioural Assessment (BAT) tool • Significant improvement in knowledge, CPT and BAT after all interventions • Although not significant, there was a trend towards improvement with high realism and scripted debriefing
High-Fidelity Hybrid Simulation of Allergic Emergencies Demonstrates Improved Preparedness for Office Emergencies in Pediatric Allergy Clinics 2013 (34)	Joshua Kennedy Stacie M Jones Nicholas Porter Marjorie L White Grace Gephardt Travis Hill Mary Cantrell Todd G Nick et al	Descriptive Study of Prospective Investigation to measure office preparedness	In office Emergency Preparedness (IOEP) 4 hour workshop CRM / teamworking 4 case based scenarios	Development of 'Harvey Training Method' based on TeamSTEPPS Clinical Emergency Preparedness Team Evaluation (CEPTE) instrument developed from TeamSTEPPS	• The Community based allergy clinic showed significant improvement in total team competency scores • The Hospital based allergy clinic showed significant improvement in total team competency
Project CAPE:A High Fidelity, In Situ Simulation Program to Increase Critical Access Hospital Emergency Department provider Comfort With Ill Pediatric Patients 2014 (11)	Jessica H Katznelson William A Mills C. Scott Forsythe Sophie Shaikh Sue Tolleson-Rinehart	Quasi Experimental: Simulated Scenario Intervention with Pre and Post Survey Evaluation	1.5 day Intensive orientation t faculty at each 'rural' hospital In Situ simulation scenarios run by local staff with organisers available to debrief 150 Eligible staff	Surveys completed at baseline / 6 months / 12 months	104 completed initial survey 32 completed all 3 surveys • Providers reported limited experience with pediatric procedures such as bag mask ventilation prior to simulation • Simulation increased comfort / confidence

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
In Situ Pediatric Trauma Simulation 2014 (35)	Marc Auerbach Linda Roney April Aysseh Marcie Gawel Jeanette Koziel Kimberly Barre Michael G Caty Karen Santucci	Descriptive Study of feasibility and impact of in situ trauma simulation programme	Between 2010 and 2012 over 24 months, monthly in situ interdisciplinary pediatric trauma simulated scenarios were held	Use of validated trauma simulation evaluation tool (included team organization, airway, intubation, breathing, circulation, disability, secondary survey)	• 398 providers in 22 unannounced simulated scenarios • Significant improvement in teamwork and intubation component • 251 completed evaluation and offered positive feedback
A Randomised Controlled Trial of In Situ Pediatric Advanced Life Support Recertification Compared with Standard Pediatric Advanced Life Support Recertification for ICU Frontline Providers 2014 (12)	Hiroshi Kurosawa Takanari Ikeyama Patricia Achuff Madeline Perkel Christine Watson Anne Marie Monachino Daphne Remy Ellen Deutsch Et al	Prospective randomized single blinded trial	Simulation-based modular Pediatric Advanced Life Support recertification training: Sessions over 6 months.	• Clinical Performance Tool (CAT) • Behavioural Assessment Tool (BAT • Questionnaire completed by participants to assess self confidence	36 subjects completed study • improvement in skills based on clinical performance tool (CPT) with simulation only • no significant difference between standard training and simulation training for teamworking based on behavioural assessment tool (BAT) • Improved confidence and satisfaction with both
Effect of Focused Debriefing on Team Communication Skills 2015 (21)	Ndidi Nwokorie Deborah Svoboda Debra K Rovito Scott D Krugman	Quasi Experimental: Educational intervention of focused debriefing	• Presentation (15 minutes) • Mock Code (20 mins) • Debriefing (30 mins) Repeated session 1 month later and 2 months later	• Participants completed an 18 item self-assessment based on Team STEPPS	22 staff from Pediatric ED and Respiratory Therapy Department Improvement in Team Communication between Session 1 and 3 particularly in the use of closed loop and speaking in loud clear voice.

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
Identifying incidents of sub optimal care during paediatric emergencies – an observational study utilizing in situ and simulation centre sceanrios 2015 (32)	Fenton O'Leary Kathryn McGarvey Andrea Christoff Jennifer Major Francis Lockie Gilad Chayen John Vassiliadis Sally Wharton	Prospective study using a combination of quantitative (observational) and qualitative	75 simulations included over 9 months in 2011 • 35 in situ ED • 20 in situ operating theatre • 20 simulation centres	Standardised proforma that included (knowledge / skill / communication etc) Thematic analysis of qualitative data	Participants • 270 doctors / 235 nurses / 11 students Causation factors highlighted as: • Loss of situational awareness • Communication failures • Knowledge deficits
Development of an instrument for a primary Airway provider's Performance with an ICU Multidisciplinary Team in Pediatric Respiratory Failure Using Simulation 2012 (3)	Akira Nishisaki Aaron J Donaghue Shawn Colborn Christine Watson Andrew Meyer Dana Niles Ram Bishnoi Roberta Hales Larissa Hutchins Mark A Helfaer Et al	Development of a Task Based Scoring System	Airway Team received simulation based airway skill training. Airway Team then assessed in a simulated scenario using 'Just in Time Pediatric Airway Provider Performance Scale Tool.	• Development of Just in Time Pediatric Airway Provider Performance Scale (JIT-PAPPS)	85 Team Performances rated by the 3 raters. • Inter rater reliability 0.64 • Correlation coefficient for global assessment and calculated assessment was 0.71 • Mean total scores were positively significantly associated with previous training and participation
Inter-professional in-situ simulated team and resuscitation training for patient safety: Description and impact of a programmatic approach 2015 (26)	Katja Zimmermann Iris Bachmann Holzinger Lorena Ganassi Peter Esslinger Sina Pilgram Meredith Allen Margarita Burmester Martin Stocker	Description of programmatic design of simulation intervention (combination of quantitative and qualitative)	Kern's Framework for curriculum development for iSTART Needs Assessment / Goals and objectives / CRM learning strategy / Monthly training sessions / Assessment of training	TeamMonitor (modified version of the Mayo High Performance Teamwork Scale	95 staff in 20 simulation scenarios < 50% confident to manage a critically deteriorating child Communication processes assessed as urgent gap 23 latent safety threats identified

Title	Authors	Methodology	Intervention	Tools	Results / Main Points
The development and implementation of an inter-professional simulation based pediatric acute care curriculum for ward health care providers 2015 (27)	Afrothite Kotsakis Karen Mercer Hadi Mohseni-Bod Rose Gaiteiro Rachel Agbeko	Descriptive Study	Development of a 1 day course Lectures Simulated scenarios Debriefing	Participants completed evaluative survey	100% of participants rated the course as excellent / very good Increased confidence Improved communication Improved understanding of roles
Teamwork Skills in Actual, In Situ, and In-Center Pediatric Emergencies: Performance levels across settings and perceptions of comparative educational impact 2015 (30)	Thomaz Bittencourt Couto Benjamin T Kerrey Regina G Taylor Michael FitzGerald Gary L Geis	Retrospective video based assessment of teamwork	132 videos reviewed • 44 clinical ED resuscitations • 44 in situ ED • 44 simulation centre	Videos reviewed by a primary reviewer • Assessed using Team Emergency Assessment Measure (TEAM) Questionnaire survey to providers to quantify experience in simulation and explore evaluation	TEAM scores were similar across settings Respondants consider simulation scenarios to improve teamworking and communication
Using Medical Simulation to Teach Crisis Resource Management and Decision Making Skills to Otolaryngology Housestaff 2015 (31)	Mark S Volk Jessica Ward Noel Irias Andres Navedo Jennifer Pollart Peter H Weinstock	Descriptive Study	Development of an in situ CRM course 5 hours ICU / Operating rooms Each Course 1 lecture 3 scenarios	No Teamwork Tools Questionnaire evaluation of course	59 individuals in 9 courses Positive evaluation

Appendix ii
Table of Original Research

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Pediatric Resuscitation: Development of a Mock Code Program and Evaluation Tool 1995 (28)	Dorothy Bishop-Kurylo Mathew Masiello	USA	PICU led	In Situ	Mock Codes conducted twice a week Assessment of skills using PMACE checklist	Unknown
Toward a new paradigm in hospital-based pediatric education: The development of an onsite simulator program 2005 (10)	Peter H Weinstock Liana J Kappus Monica E Kleinman Barry Grenier Patricia Hickey Jeffrey P Burns	USA	PICU led	In Situ	> 1500 learning encounters per year	129 individuals from 7 departments
Evaluation of a Multidisciplinary Pediatric Mock Trauma Code Educational Initiative: A Pilot Study 2006 (6)	Angelo Mikrogianakis Martin H Osmond Janet E Nuh Allyson Shepherd Isabelle Gaboury Mona Jabbour	Canada	Emergency Medicine (ED)	In Situ	1 hour educational session with 2 x 15 minute codes	37 Trainees
Impact of a Pediatric Primary Care Office-based Mock Code Program on Physician and Staff Confidence to Perform Life-saving Skills 2006 (4)	Seth L Toback Melinda Fiedor Brian Kilpela Evelyn Cohen Reis	USA	Pediatric Primary Care	In Situ	2 hour educational session: • Staff education / emergency protocols • 10-15 minute mock code • 30 minute debriefing	164 physicians and staff from 11 group pediatric practices 97 (59%) completed both surveys

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Simulated Pediatric Trauma Team Management 2007 (5)	Elizabeth A Hunt Margaret Heine Susan M Hohenhaus Xuemei Luo Karen S Frush	USA	Emergency Departments	In Situ	Pre intervention • One simulated mock code Post Intervention • Debriefing • Discussion • Distribution of manual / tape Repeat mock code 6 months later	18 sites 17% of EDs North Carolina) 'Teams' observed
Simulation of In – Hospital Pediatric Emergencies and Cardiopulmonary Arrests: Highlighting the Importance of the 5 minutes 2007 (8)	Elizabeth A Hunt Allen R Walker Donald H Shaffner Marlene R Miller Peter J Provonost	USA	Ward Based	In Situ	34 consecutive unique mock codes over 40 months	34 first responder and code teams
Multidisciplinary pediatric trauma team training using high fidelity trauma simulation 2008 (18)	Richard A Falcone Jr Margot Daugherty Lynn Schweer Mary Patterson Rebeccah L Brown Victor F Garcia	USA	Trauma Resuscitation Team	Simulation Suite	Educational Innovation • Team function and Communication incorporated into activities sessions • 23 X 2 hour sessions over 12 months (46 trauma scenario)	160 members of multidisciplinary team

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Enhancing Nurse-Physician Collaboration Using Pediatric Simulation 2008 (33)	Patricia R Messmer	USA	Pediatrics	Simulation Suite	Multidisciplinary team exposed to 3 scenarios • Videotapes reviewed by independent scorers and scored on the Kramer Schmalenberg Nurse Physician Scale • Participants also completed validated instruments for collaboration and cohesion	105 participants of 18 teams • 55 pediatric residents • 50 nurses
Simulation at the point of care: Reduced-cost, in situ training via a mobile cart 2009 (25)	Peter H Weinstock Liana J Kappus Alexander Garden Jeffrey P Burns	USA	PICU	In situ	57 courses over 3 years	425 participants
Effect of Just-in-time Simulation Training on Tracheal Intubation Procedure Safety in the Pediatric Intensive Care Unit 2010 (22)	Akira Nishisaki Aaron J Donaghue Shawn Colborn Christine Watson Andrew Meyer Dana Niles Ram Bishnoi Roberta Hales et al	USA	PICU	In Situ	Educational innovation • 20 minute multidisciplinary tracheal intubation training • 10 minute resident skill refresher prior to shift 202 simulation events 401 consecutive intubations analysed (220 pre and 181 post)	265 individuals • 78 Residents • 122 PICU nurses • 65 Respiratory Therapists

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Simulation- based training delivered directly to the pediatric cardiac intensive care unit engenders preparedness, comfort, and decreased anxiety among multidisciplinary teams 2010 (13)	Catherine K Allan Ravi R Thiagarajan Dorothy Beke Annette Imprescia Liana J Kappus Alexander Garden Gavin Hayes Peter C Laussen Emile Bacha Peter H Weinstock	USA	Paediatric Cardiology	In Situ	Establishment of pCICU-CRM course of 4 ½ hours that is run monthly • Game play • 45 minute interactive lecture • Video review • Scenarios and debriefing 27 courses over 33 months	182 Health Care Providers
Medical Simulation Topic Interests in a Pediatric Healthcare System 2010 (20)	Ellen S Deutsch Jason J Olivieri Jabayer Hassain Heather L Sobolewski	USA	Pediatric Staff	N/A	Web based survey addressing medical simulation experience / simulation interests / demographics	1165 Individuals surveyed • 490 responses (physicians, nurses, other)
Simulation to Assess the Safety of New Healthcare Teams and New Facilities 2011 (1)	Gary L Geis Brian Pio Tiffany L Pendergrass Michael R Moyer Mary D Patterson	USA	Emergency Department	Simulation Centre and subsequent In Situ	24 critical patient scenarios over 4 sessions. • 2 x 4 hour centre sessions • 2 x 8 hour in situ sessions	81 health care providers (mostly nurses, paramedics, physicians)
Simulation-based mock codes significantly correlate with improved pediatric patient cardiopulmonary arrest survival rates 2011 (23)	Pamela Andreatta Ernest Saxton Maureen Thompson Gail Annich	USA	Code Team members	Simulation Centre or / In Situ	Mock Codes called randomly at least monthly with increasing rates over 2 years • Emphasis on developing leadership in residents	252 resident responses to self assessment

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Integrated In-Situ Simulation Using Redirected Faculty Educational Time to Minimise Costs: A Feasibility Study 2011 (9)	Aaron W Calhoun Megan C Boone Eleanor B Peterson Kimberly A Boland Vicki Montgomery		PICU			
Impact of an embedded simulation team training programme in a paediatric intensive care unit: a prospective, single centre, longitudinal study 2011 (14)	Martin Stocker Meredith Allen Natasha Pool Kumi De Costa Julie Combes Neil West Margarita Burmester	England	PICU	In situ	Simulation Program: Each session 2 hours in length • Introduction • Simulated Scenario • Debriefing Every 1-2 weeks.	219 health care professionals
Impact of multidisciplinary simulation-based training on patient safety in a paediatric emergency department 2012 (15)	Mary D Patterson Gary L Geis Thomas LeMaster Robert L Wears	USA	Paediatric Emergency Department	In Situ	Educational Intervention: • E learning resource on CRM • Safety Attitudes Questionnaire • Knowledge pre test • 5 simulations with debriefing 33 classes from March 2005 to March 2008 - 12 hours (reduced to 4 hours) Re-evaluation at 6 months 36 re-evaluation classes	289 participants in initial training 151 participants followed up

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
In Situ simulation: detection of safety threats and teamwork training in a high risk emergency department 2012 (7)	Mary D Patterson Gary Lee Geis Richard A Falcone Thomas LeMaster Robert L Wears	USA	Paediatric Emergency Department	In Situ	Unannounced trauma and medical simulation scenarios 1-2 times per week • 10 minute simulation • 10 minute debriefing 90 simulations over 1 year	218 healthcare providers (physicians, nurse, paramedic, respiratory therapist, others)
Improving Teamwork, Confidence, and Collaboration Among Members of a Pediatric Cardiovascular Intensive Care Unit Multidisciplinary Team Using Simulation-Based Team Training 2013 (24)	Mayte I Figueroa Robert Sepanski Steven P Goldberg Samir Shah	USA	Cardiology	Simulation Center	Simulation course of 9 hours • Didactic lectures • Simulated scenarios developed from previous emergencies • TeamSTEPPS principles • Debrief • Questionnaire	37 participants
Regular in situ simulation training of paediatric Medical Emergency Team improves response to deteriorating patients 2012 (17)	U Theilen P Leonard P Jones R Ardill J Weitz D Agrawal D Simpson	Scotland	Medical Emergency Team on Wards (ED / PICU / Wards)	Simulation Centre / In Situ	Weekly 2 hour protected teaching for Medical Emergency Team (pMET) • Included 2 scenarios with debriefing Each team members attended between 4-10 training sessions	Unclear

Title	**Authors**	**Country**	**Department**	**Center or In situ**	**Number / Frequency / characteristics of sessions**	**Numbers of Participants**
High-reliability emergency response teams in the hospital: improving quality and safety using in situ simulation training 2013 (16)	Derek S Wheeler Gary Geis Elizabeth H Mack Tom LeMaster Mary D Patterson	USA	PICU / OR / CICU / Patient care units	In situ	Educational Intervention: 112 standardized simulation scenario scheduled twice each month on inpatient wards and once each month on PICU or CICU • 64 unannounced 10 min simulations from January 2008 to September 2009 with 10 min debriefing Each inpatient ward participated in at least 2 scen	596 Participants (nurse, physician, respiratory therapist, patient care assistant, pharmacist, surgical technician, others)
Examining Pediatric Resuscitation Education Using Simulation and Scripted Debriefing 2013 (29)	Adam Cheng Elizabeth A Hunt Aaron Fonoghue et al EXPRESS Investigators	USA	Multicenter pediatric tertiary care	Simulation Centre	Four study groups Non scripted debriefing and low physical realism Scripted debriefing and low realism Non scripted debriefing and high physical realism Scripted and high physical realism	Total of 453 participants • Medical • Nursing • Respiratory therapists
High-Fidelity Hybrid Simulation of Allergic Emergencies Demonstrates Improved Preparedness for Office Emergencies in Pediatric Allergy Clinics 2013 (34)	Joshua Kennedy Stacie M Jones Nicholas Porter Marjorie L White Grace Gephardt Travis Hill Mary Cantrell Todd G Nick et al	USA	Primary and Secondary Care	Simulation Centre	Participation in 4 hour Workshop 4 case-based scenarios videoed / Debriefing TeamSTEPPS CEPTE evaluation of videos 10-12 months later Unannounced In Situ simulation / debriefing	26 participants • 10 physicians • 16 Nurses

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Project CAPE: A High Fidelity, In Situ Simulation Program to Increase Critical Access Hospital Emergency Department provider Comfort With Ill Pediatric Patients 2014 (11)	Jessica H Katznelson William A Mills C. Scott Forsythe Sophie Shaikh Sue Tolleson-Rinehart	USA	ED	In Situ	5 Institutions: Voluntary participation by staff Educational Intervention: • Each completed 6 Unique Simulated Scenarios ***at least once*** over 12 months All eligible staff sent survey pre and post simulation	150 eligible staff 104 completed baseline survey 61 completed two 32 completed all three
In Situ Pediatric Trauma Simulation 2014 (35)	Marc Auerbach Linda Roney April Aysseh Marcie Gawel Jeanette Koziel Kimberly Barre Michael G Caty Karen Santucci	USA	ED	In Situ	22 unannounced monthly pediatric trauma simulations • Simulation Scenario 20 minutes • Debriefing 30 minutes • Use of validated trauma simulation evaluation tool • Feedback questionnaire	398 Participants which included all multidisciplinary staff working in ED Follow up report of latent errors
A Randomised Controlled Trial of In Situ Pediatric Advanced Life Support Recertification Compared with Standard Pediatric Advanced Life Support Recertification for ICU Frontline Providers 2014 (12)	Hiroshi Kurosawa Takanari Ikeyama Patricia Achuff Madeline Perkel Christine Watson Anne Marie Monachino Daphne Remy Ellen Deutsch et al	USA	Realistic Clinical Environment on PICU	In Situ	Educational Intervention: • Intervention group had PALS delivered as 6 shorter training sessions including in situ simulation delivered monthly	40 subjects (nurses, respiratory therapists, nurse practitioners)

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Effect of Focused Debriefing on Team Communication Skills 2015 (21)	Ndidi Nwokorie Deborah Svoboda Debra K Rovito Scott D Krugman	USA	Pediatric Emergency and Respiratory Therapy		Three month initial intervention • Simulated 20 min resuscitation sessions • 30 minute debriefing • Survey on observed communication Repeat with same team and same scenario Repeat with same team and different scenario	22 volunteers of pediatric emergency and respiratory therapy departments
Identifying incidents of sub optimal care during paediatric emergencies – an observational study utilizing in situ and simulation centre sceanrios 2015 (32)	Fenton O'Leary Kathryn McGarvey Andrea Christoff Jennifer Major Francis Lockie Gilad Chayen John Vassiliadis Sally Wharton	Sydney Australia	Emergency Department		9 month study of 75 interprofessional paediatric simulation scenarios • Standardised Centre and In Situ simulation program • Recording of incidents using a standard proforma • Causation factors identified during debriefing	270 doctors 235 nurses 11 medical and nursing students with additional observers
Development of an instrument for a primary Airway provider's Performance with an ICU Multidisciplinary Team in Pediatric Respiratory Failure Using Simulation 2012 (3)	Akira Nishisaki Aaron J Donaghue Shawn Colborn Christine Watson Andrew Meyer Dana Niles Ram Bishnoi et al	USA	PICU	In SItu	Linked to 'Just in Time' Two scenarios involving tracheal intubation randomly used Development of Pediatric Airway Provider Performance Scale	85 Team Performances

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Inter-professional in-situ simulated team and resuscitation training for patient safety: Description and impact of a programmatic approach 2015 (26)	Katja Zimmermann Iris Bachmann Holzinger Lorena Ganassi Peter Esslinger Sina Pilgram Meredith Allen Margarita Burmester Martin Stocker	Switzerland	Paeds	In Situ	20 Training sessions delivered monthly • Each lasting 2 hours • CRM principles • Scenario • Debriefing • TeamMonitor (modified Mayo High Performance Teamwork scale	95 interdisciplinary staff • 50 nurses • 45 physicians
The development and implementation of an inter-professional simulation based pediatric acute care curriculum for ward health care providers 2015 (27)	Afrothite Kotsakis Karen Mercer Hadi Mohseni-Bod Rose Gaiteiro Rachel Agbeko	Canada / UK	PICU	Simulation Centre	4 courses over 2 ½ years 1 day course • Maximum of 25 people per course • Interactive lectures • Simulation scenarios - 10 minutes in length • Debrief – 20 minutes	89 participants • 51 nurses • 38 paediatric residents
Teamwork Skills in Actual, In Situ, and In-Center Pediatric Emergencies: Performance levels across settings and perceptions of comparative educational impact 2015 (30)	Thomaz Bittencourt Couto Benjamin T Kerrey Regina G Taylor Michael FitzGerald Gary L Geis	Brazil	ED	Simulation Centre and In situ	Context of well established simulation training with review of videos using TEAM tool from following situations • Simulation Centre simulation scenarios *15-20 mins simulation and 30-35 minutes debrief* • In Situ simulation scenarios *10 mins simulation and 10 mins debrief* • Actual ED real scenarios	132 videos (44 from each setting) Separate survey of 154 practitioners of whom 99% had experienced simulation.

Title	Authors	Country	Department	Center or In situ	Number / Frequency / characteristics of sessions	Numbers of Participants
Using Medical Simulation to Teach Crisis Resource Management and Decision Making Skills to Otolaryngology Housestaff 2015 (31)	Mark S Volk Jessica Ward Noel Irias Andres Navedo Jennifer Pollart Peter H Weinstock	USA	Department of Otolaryngology	In Situ	9 courses of 5 hours • Introduction • Simulation scenario lasted between 15 -45 minutes • Debrief • Scenario and debrief repeated twice • Final review and summary	59 participants 18 Otolaryngology residents 7 Otolaryngology fellows 20 OR nurses 4 CRNAs 10 Anaesthesia Residents or fellows

Appendix iii
Table: Summary of Review Papers ordered by publication year

Title	Authors	Methodology	Results / Main Points	Country / Other Points
Resuscitation training of paediatricians 2003	F Jewkes B Phillips	Review of Resuscitation Training	Describe need for training and history of resuscitation courses • Review importance of faculty having instructor training • Look at evidence for resuscitation courses Discussed area of skill retention	Wiltshire, United Kingdom
New aspects on critical care medicine training 2004	Ake Grenvik John J SchaeferMichael A DeVita Paul Rogers	Review Article	Three fundamental changes in clinical education: • Evidenced based medicine • Patient Safety • Use of simulation Outlines advantages of simulation training	Pennsylvania, USA
The patient died, but we can try again: simulation in pediatric critical care training 2005	Rainer Gedeit	Editorial	Refers to paper describing development of Boston Children's Hospital Simulation Centers. • Financial / Proximity to clinical space • Volunteer Faculty / Development of validated clinical scenarios • Multidisciplinary educators and learners	Milwaukee, USA
Emergency and critical care pediatrics: use of medical simulation for training in acute pediatric emergencies 2006	Walter J Eppich Mark D Adler William C McGaghie	Review Article	• Simulation as a training strategy • Concept of deliberate practice Key features of simulation including integration into the curricula	Chicago, USA

Title	Authors	Methodology	Results / Main Points	Country / Other Points
Simulation in paediatrics: An educational revolution 2007	Adam Cheng Jonathon Duff Estee Grant Niranjan Kissoon Vincent J Grant	Authors Review of simulation in paediatrics	• Definition of Simulation • How realism is achieved Benefits of Simulation	Description of Paediatric Simulation in Canada
Simulator-based training in paediatric anaesthesia and emergency medicine – Thrills, skills and attitudes 2007	C Eich A Timmermann S G Russo E A Nickel J McFadzean D Rowney S K W Schwartz	Review - Editorial	• Effective application of non technical skills requires non technical skills • Simulation-based training can enhance • Simulator Training of Clinical Teams becomes increasingly important	Germany, United Kingdom
Bridging the knowledge-resuscitation gap for children: Still a long way to go 2007	Ran D Country Kendall Ho Robert Peterson Niranjan Kissoon	Review Article	Discussion of evidence for translating knowledge to practice including: • Interactive workshops • Outreach visits with opinion leaders • Resuscitation courses / Mock codes • Discussion of stress and uncertainty in real life acute events	Toronto and British Columbia, Canada
Team Training: implications for emergency and critical care pediatrics 2008	Walter J Eppich Melissa Brannen Elizabeth Hunt	Review Article	• Team and Teamwork / Teams and communication / Learning from other Industries / Team Training in Emergency Medicine / Team Training in Pediatrics / Multidisciplinary Teams	Chicago and Baltimore USA
Teamwork in pediatric heart care 2009	R Krishna Kumar	Review Article	Key requirements of a cohesive team: • Level of skill and experience / Mutual trust and respect / Understanding roles and personalities / Communication / Collective sense of responsibility / Review of performance	Kochi, India

Title	Authors	Methodology	Results / Main Points	Country / Other Points
The use of simulation for pediatric training and assessment 2009	Eric R Weinberg Marc A Auerbach Nikhil B Shah	Authors review of simulation in paediatric training and assessment	Evidenced based review for role of simulation in: • Resuscitation • Trauma management • Airway management • Procedural Skills • CRM Disaster / mass casualty training	New York, USA In consideration of the use of simulation for assessment Few tools well validated
Simulation-based crisis resource management training for pediatric critical care medicine: A review for instructors 2011	Adam Cheng Elaine Gilfoyle Walter Eppich	Review Article	• Defining a team • Principles of Crisis resource Management • Applicability to Pediatric Resuscitation • Simulation based education for CRM training • Debriefing Strategies Assessment of CRM performance	University of Calgary / University of Columbia / Northwestern University Canada
Training using medical simulation 2012	David J Grant Stephen C Marriage	Authors Review of Medical Simulation in paediatric practice and description of Bristol Paediatric Simulation Program	Discussed areas such as: • Development of Medical simulation • Effectiveness of Medical Simulation • Educational Theory • Matching Simulation to formal training requirements • The future	Bristol, United Kingdom Description of Bristol Paediatric Simulation Program
Weathering the perfect storm: A deeper look at simulation applied to pediatric critical care 2012	Peter Weinstock	Editorial	A refocusing on structured process for each pedagogical element • Objectives • Scenario design • Signal to noise ratio • Program sustainability	Boston, USA

Title	Authors	Methodology	Results / Main Points	Country / Other Points
Team training – The BEST approach to continuing education in resuscitation 2013 (19)	Hildigunnur Svavarsdottir Guttorm Brattebo	Review of simulation in resuscitation with specific description of the BEST innovation in Norway	Discussed Pedagogical principles including: • in situ, cross-professional, simulation • establishment of informal network Description of BEST educational innovation in Norway • One day course that focuses on optimal team function and hierarchal progression of patient assessment and management	University of Akureyri, Iceland And Bergen Norway
Optimisation of simulated team training through the application of learning theories: a debate for a conceptual framework 2014	Martin Stocker Margarita Burmester Meredith Allen	Review of learning theories and their application to simulation	Organised under specific debates: • Debate 1: Single versus repeat exposure • Debate2:Simple experience versus experience of failure • Debate 3:Individual reflection versus critical reflection in the group • Debate 4: Improvised versus real teams • Debate 5: Simulation centre versus in-situ simulation	Lucerne Switzerland

The role of simulation in teaching pediatric resuscitation: current perspectives
2015
	Yiqun Lin
	Adam Cheng
		Literature Review of simulation in resuscitation training	• Neonatal Resuscitation
			  ○ Variable results
			  ○ One study showed reduction in HIE
			• Paediatric advanced life support
			  ○ Simulation incorporated into curricula
			  ○ Potential benefits
			• CRM
			  ○ Increasing evidence of effectiveness
				Calgary, Canada
				
				Discussion of technical skills and distributed practice / instructional design and future directions

Title	Authors	Methodology	Results / Main Points	Country / Other Points
Simulation-based Medical Education: Time for a Pedagogical Shift 2015	Kaarthigeyan Kalaniti Douglas M Campbell	Authors Review of the role of Simulation in Medical Education	Discussed areas such as: • Evolution of simulation • Educational methodologies • Role of stress in simulation • Fidelity (authenticity) in Simulation • Stages of Simulation • Competency assessment • Simulation Facility • Limitations	University of Toronto Canada

HIE: Hypoxic Ischemic Encephalopathy

Appendix iv
Review Articles: Categories and Sub Categories

Education	Simulation Specific	Technical Skills	Non Technical skills	Teamwork	Patient Safety	Assessment
Faculty / Instructor Training	Simulation scenario design eg Variation in signal:noise ratio	Concept of deliberate and distributed practice		Key requirements of a cohesive team	Identification of latent or system based	Assessment of training course • Certification / Accreditation
Instructional design	Debriefing Strategies	Airway	Decision making	Leadership	Rare clinical events	Acquire and maintain expert performance/ skill retention
Identification of performance gaps (theory to practice)	Structured clinical approach to common situations	Repetitive performance	Communication: Documentatio	Collaboration: Interdisciplinary and interdepartmental	Mutual respect and trust	Changes in attitude
Evidenced based education	Simulation center or In-Situ		Communication: Information sharing	Real Teams or improvised	Culture and Hierarchy	Assessment tools for measurement of team performance
Integration of simulation based interventions into the curricula	Concept of fidelity	Resuscitation Training	Repeat back or closed loop	Crisis Resource Management (CRM)	Assessment of Improved Patient Outcome	Assessment tools for measurement of Team Leader
Training without patient risk	Synergy between simulations and real life clinical experience	Trauma	Dealing with disagreement	CRM: Learning from other industries	Incorporating specific patient safety	Changes in Behaviour
Modular approach	Roles of stress	Procedural skills	Situation awareness		Needs analysis	Is CRM effective
Reflection; individual vs group	Scenario design	Task management				Transfer of technical and non technical skills into clinical practice
Educational theory / methodology		Effective application of technical skills requires non technical skills				Competency Assessment

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Appendix v

Human Ethics Committee – Application Form

For Office Use Only –
HEC Reference: 2015/05/LR - MEEKS **Date Received: Resubmitted 22/03/2015**

Please remember that your audience for this application form, as well as all forms for participants, will include community members and scholars from outside your discipline and therefore must be written in everyday language.

This form should be completed after reading the *Human Ethics Policy* issued by the Human Ethics Committee available at http://www.canterbury.ac.nz/humanethics

Please ***Bold*** your answers

Description of the Project

1. What does the project seek to do?

This aim of this project is to examine the evidence for interprofessional crisis resource management (CRM) simulation based learning in paediatric clinical care. The evidence will include a literature review as well as other publicly available resources which will be chelated with the opinions and experiences of international and national leaders in this area. This is a participatory research project designed to inform practice development and an assumption is that some of the barriers to establishing an embedded culture of teaming using CRM simulation in Pediatrics will be shared within and between countries, and it may be that the solutions they have identified are of value to others.

2. What is the research question or hypothesis of this project?

Postgraduate In Situ Simulation within a Hospital Setting with a focus on Crisis Resource Management and Team Training in Acute Care Paediatrics: Where are we and where should we be?

3. Describe how this project arose (ie, please explain the academic area or issue etc which generated the question(s) to be examined – this is to allow lay members of the committee some context for the research.)

Crisis Resource Management (CRM) is a term that has developed from crew resource management in the airline industry. It refers to those non-technical cognitive and social skills that have a crucial role in minimising patient harm and maximising collaborative teamwork in the acute situation. CRM includes

the concepts of leadership, role clarity and closed loop communication (clarification that a message has been received). In a similar way to within the airline and other industries simulation of those 'rare but critical' medical emergencies can be used to practice these skills and to provide the opportunity for debriefing. The South Island of New Zealand does not have a Paediatric Intensive Care Unit (PICU) and critically ill children are stabilised and managed for a short period of time with input from adult intensive care specialists and paediatricians and then transferred to Auckland Hospital. The numbers of critically ill children is fortunately small but in view of this the health professionals involved will not be as experienced as their PICU colleagues in Auckland in the management of these situations. CRM simulation training is already being developed within Christchurch Hospital Paediatric Department and I wanted to have the opportunity to review the literature and the experience of leaders within this field to inform its further development.

4. How will you go about answering the research question?

The methods can be considered in three parts:
Critical (or focused review) of the literature, both published peer reviewed literature as well as other publicly available information such as international conference proceedings, podcasts etc. This will be informed by my own involvement in simulation and the professional conversations and personal communications that form an integral part of this project.
Focused observation of Paediatric Simulation Scenarios within two international centres of excellence and engagement of the staff of these centres in semi-structured conversation to ascertain their views on the enablers and barriers to establishing a paediatric simulation program in acute care pediatrics as well as the core features of any simulation program. These visits have already been arranged.
Focused observation and interview, in a similar way to above, with staff conducting acute care paediatric simulation in two District Health Boards (DHB) within New Zealand. A visit to one of the DHBs is planned for March and I work within the second DHB and will explicitly discuss any areas of bias within the thesis.

Information about the Participants

5. Who are the participants and why have they been chosen to be asked to participate? Please include statistical justification where necessary.

I have been given access to two international simulation programs through Professor Peter Weinstock, SIMpeds (http://simpeds.org), in Boston and Lydia Lofton, SPRinT (http://sprintsimulation.co.uk), in London. Their contact details are below and I am happy to forward our original correspondance regarding the visits:

Dr Peter Weinstock
Boston Children's Hospital
Longwood Avenue
Boston
Massachusets
Email: Peter.Weinstock@childrens.harvard.edu

Lydia Lofton
Royal Brompton Hospital
Royal Brompton and Harefield NHS Trust
London
UK

Email: L.Lofton@rbht.nhs.uk

Nationally I have been invited to participate in a Neonatal Intensive Care Unit Crisis Resource Management session at Starship Auckland (I have previously observed) and to speak to Dr Mike Shepherd who is one of the leads in the development of paediatric simulation based learning at Starship Hospital Auckland. His contact details are below:

Dr Mike Shepherd
Consultant ED Physician
Starship Hospital
Auckland
NZ
Email: MichaelS@adhb.govt.nz

All of these centres have communicated with me via email and are happy to share their ideas and innovations with me and it is likely that most of this information is already within the public domain. Any resulting publication will acknowledge their essential contribution to this work. No specific individual aside from those already known to be leading the simulation programs will be identified and specifically those students / professionals undergoing simulation training will not be identified.

6. How many participants will be involved (of each category where relevant)?

The main participants will be those with whom I have liaised who are mentioned above, Peter Weinstock, Lydia Lofton, Mike Shepherd. I may have the opportunity to speak with representatives from academic, clinical, technical and administrative staff involved in the Pediatric Simulation Programs but this has not been formerly arranged as a core part of the project and the individuals will not be identified as part of the project..

7. What selection criteria and/or exclusion criteria will you use? Ie, randomly, by age, gender, ethnic origin, other – please give details. What plans do you have if the recruitment phase is too successful, or does not recruit enough participants?

Any staff involved in a program conducting acute care paediatric simulation in the four centres will be eligible to share information about the program, their involvement and details about the program. As the participant in this research the aim is that I obtain a variety of perspectives from those working in simulation but this will not involve explicit selection and exclusion criteria in a formalised way.

8. Describe how potential participants will be identified and recruited?

Through the leaders of the simulation programmes (who have already been contacted and have given permission).

9. Does the project involve recruitment through advertising? (delete inapplicable) If yes, please attach a copy of all variations of this advertising (including e-advertising, eg, Facebook) and discuss any permissions that you have or might need to seek (eg, from organisers of social media/blog/comments pages).

NO

10. How much time are participants asked to contribute to the research?

The maximum interview time will be 1 hour. Follow up email may be used to confirm factual information.

11. Is any form of inducement to be offered? NO (delete inapplicable) If yes, please justify, and include the funding source for the inducements.

NO.

12. How will the participants be treated? Describe in practical terms how the participants will be treated, what tasks they will be asked to perform, etc. Indicate how much time is likely to be involved in carrying out the various tasks.

N/A.

Other parties with an interest in the research

13. Does the project require permission of an organisation, other people, to access participants or information? (delete inapplicable) eg, parents, guardians, school principals, teachers, boards, responsible authorities including employers, etc. If yes, please explain how this approval has been or will be obtained, enclosing copies of relevant correspondence. *Please ensure forms make the employers/organisations aware that even once they have given permission in principle to give you access to participant information, they will not be able to provide this until you have obtained agreement from the participants themselves.*

    Yes – each site and centre I am visiting has granted me access and permission

14. Will the project require Maori consultation? **NO** (delete inapplicable) ie, will it involve largely Maori populations or resources or will the ethnicity of participants be recorded and be likely to result in different treatment for Maori participants during the study or result in statements specifically about Maori in the results? Please provide evidence that consultation has occurred or, if underway, with whom consultation is taken place – including their contact details. Once approvals are obtained please forward copies to HEC. *Please note: the HEC understands that in many cases consultation is informal, and does not produce official approval documents. In such cases, simply note with whom consultation has taken place, why it is those particular bodies, and include their contact details of those with whom you have consulted.*

Please explain whether or not your research is of interest to particular Maori organisations, and your contact with those groups. For help with finding out whether Maori organisations might have an interest in your research and how to start consulting, please see the University's Maori research consultant. All research in which Ngai Tahu may have an interest must be discussed with the University's Ngai Tahu Research Centre.

For further information:
http://www.research.canterbury.ac.nz/maoriresearch/maoriconsultation.shtml

It is hoped that this project will be of interest to individuals of all ethnicities working within healthcare involving the acute care of children and their families.

15. Will the project require Community consultation? **NO** . (delete inapplicable) ie, will it involve largely one community or that community's resources, or is it likely to result in different treatment for a community or result in statements specifically about a community in the results (eg, a geographically bounded community, a community of like-minded individuals, a community of hobbyists, employees)? A useful, though not exhaustive test of whether a community ought to be consulted, is whether that community has a leadership group that can be consulted. Once approvals are obtained please forward copies to HEC. *Please note: the HEC understands that in many cases consultation is informal, and does not produce official approval documents. In such cases, simply note with whom consultation has taken place, why it is those particular bodies, and include their contact details of those with whom you have consulted.*

16. Is the project funded externally? **NO** (delete inapplicable) If yes, please provide details and discuss any conflict of interest issues that may arise.

17. Is the project commissioned by or carried out on behalf of an external organisation(s)? **NO** (delete inapplicable) If yes, please provide details and discuss any conflict of interest issues that may arise.

This is a participatory research project and an investigative and observational study in an area of personal interest with the aim of developing practice. I am working entirely independently but in view of the importance of the area I have been asked to prepare a summary report on this research for CDHB. This will be written as the personal opinion of someone working within simulation in their organisation who has investigated the area. It will be written as a summary of my findings that is framed as a model for organisational improvement in this area. It will not contain any information that is not in the dissertation and it will not personally identify any individuals working for CDHB. This summary report will also be routinely shared with the leaders of the simulation programs visited as part of the research.

18. Is the project to be part of the CEISMIC digital archive? **NO** If so, please ensure all participants are made aware of this, and have filled in the UC CEISMIC Quake Studies consent form. See www.ceismic.org.nz.

Data collection

19. Does the project involve a questionnaire? **NO** (delete inapplicable) If yes, please include a copy. The HEC does not normally approve a project which involves a questionnaire without seeing the questionnaire, although it may preview applications in some cases where the production of the questionnaire is delayed for good reason. If there is a questionnaire please answer the following questions:

    (a) Explain how and why the questionnaire(s) will be anonymous or confidential (Anonymous: you could ***not*** conceivably know who completed it; Confidential: not anonymous, but you will not reveal the identity of the participants to anybody outside the research team)

    (b) Explain how the questionnaire will be distributed and collected.

20. Does the project involve a structured or semi-structured interview? **YES** (delete inapplicable) If yes, please list the topics or the specific questions to be covered.

    This will be developed following the literature review and initial observation at one of the international centres. The likely topics that will be included are:

    - **Challenges and barriers to establishing and embedding a Paediatric CRM simulation program**
    - **Enablers to establishing and embedding a Paediatric CRM simulation program**
    - **Frequency of CRM simulation sessions run by paediatric simulation program**
    - **Frequency with which an individual health professional will be required to undergo CRM simulation sessions**
    - **Local evidence for the effectiveness of the CRM sessions**

21. Does the project involve an unstructured interview? **NO** (delete inapplicable) If yes, please list the topics to be covered.

22. Does the project involve focus groups? **NO** (delete inapplicable) If yes, please include a copy of the confidentiality agreement all participants will sign or explain the way that you will protect the confidentiality of participants.

23. Does the project involve recording of Audio, Video or Images? **NO** (delete inapplicable) If yes, please explain the purpose and describe the recording. Please ensure information sheets fully inform participants of the extent and nature of the recording, and explain the legal and ethical issues of ownership of these recordings and how you have resolved them.

24. Will participants will be given the opportunity to check the transcript and/or notes of their interview/focus group? **YES** (delete inapplicable) It is normal practice to give participants the opportunity to review their transcription. If this is not to be the case, please explain why you believe it is not necessary. Participants must be informed of interview recording both in the information sheet and at the time of the recording, and the process by which they can review the related transcription. *Please note that transcripts of focus groups may raise privacy issues (particularly if the participants are children, since other parents will see comments by children who are not their own).*

The semistructured interview is predominantly aimed at obtaining quantitative factual information about the simulation program rather than qualitative information. These facts will be verified with the relevant organisations prior to submission of the thesis.

Informed and Voluntary Consent

Please note: The HEC recommends that participants receive an information sheet, which they must be able to retain, unless there are good reasons for not adopting such a procedure.

The information sheet(s) and the consent form(s) should be separate. Projects which **only** involve an anonymous questionnaire may not necessarily require a separate information sheet, provided that the questionnaire includes your name and contact number as well as the other points contained in the information and consent templates available on the HEC website. *Please note: so that participants can retain a copy of the information sheets, the information sheet(s) and the consent form(s) should be separate.*

25. By whom and how will information be given to potential participants? Please attach a copy of the information sheet and consent form (if email/internet, please provide a screen shot), or the oral briefing script. Also, please set out in precise detail the processes used to obtain consent, and ensure that those processes allow the participant the opportunity to say no or withdraw without stress, embarrassment or difficulty. Where you do not intend to gain written consent, (ie, where you will rely on oral consent etc) please justify and explain how you will gain consent.

This is an investigative and observational study. There will be no information pertaining to patients as part of this research study. There will be no educational or learning innovations instigated within the confines of this study. I have already been invited to visit the international and local centres and been given consent in advance of this proposal to observe and interview staff involved with their simulation programs. I have prepared an information sheet to ensure that all participants have standardised information and contact details.

26. Are all participants competent to give consent on their own behalf? (delete inapplicable) As a rule, children and young adults under the age of 16 years (or 18 years if still at school) will require parental consent to participate in your research, as do adults who have impairments that limit their capacity to represent themselves. All such participants unable to give consent should still receive a suitable information sheet and assent form where practicable. It is possible in some cases that respect for the autonomy will override concerns over ethical and legal competency, but these are rare and require much justification, and usually only arise in the context of a general community approval to waive competency requirements.

The Program leaders have already given their permission for me to speak with them and observe practice. If they have arranged or I am given the opportunity to interview others within the program, the interviews will be conducted in the form of a conversation between colleagues involved in simulation. I have not arranged a formal consent process as the information pertains to the program and not to the individual.

If no, please explain,

(a) why they are not competent to give informed consent on their behalf?

(b) how consent will be obtained in the absence of that competency?

(c) if applicable, how will assent to participate be gained?

Privacy and Confidentiality

27. Will information pertaining to or about the participants be obtained from any source other than the participant? **NO** (delete inapplicable) If yes please state:

No specific individual aside from those already known to be leading the simulation programs will be identified and specifically those students / professionals undergoing simulation training will not be identified

(a) the identity of the third party or parties.

(b) why such information is needed.

(c) how will you obtain consent from the participant and the third party(ies) to gather that data. Please ensure the information sheet is very clear about any data gathered about participants from third party participants, and how you intend to gain permission to see the data.

(d) the processes you will use to obtain that data. If you are using recruitment strategies that access potential participants via a third party please discuss your specific methods here. In general, it is not legal for your participants to give private contact details of other people to you. Usually, should you wish to snowball recruit, you should give your participants an information sheet or advertisement that they can give to others, in the hope that those third parties will then contact you.

It may happen that by virtue of your job, you have right of access to information concerning the participants. Where information has been collected from individuals for a purpose other than your research, it is probable that potential participants will need to be informed that their agreement to participate may involve such use. Guidance on privacy can be found in the polices of the University, and on the website of the Privacy Commissioner.

28. Is information that identifies participants to be given to any person outside the research team, or if identification of or attribution of comments by participants is sought, please explain how and why. **NO** (delete inapplicable) If yes, please explain how and why and include this in the information and consent forms.

29. Please explain how confidentiality of the participants' identities will be maintained in the treatment and use of the data. **N/A** eg, the HEC expects that researchers will attempt to ensure that stored data is separated into identifying data (eg, consent forms, coding forms), and de-identified (eg, coded data, de-identified transcripts): typically this is done by assigning participants a code on the consent form, and using that code on any data, transcripts, etc. Where this is too difficult, please explain why.

30. Is an institution (eg, school, business, etc) to which participants belong to be named or be able to be identified in the publication or presentation of this project? **YES** (delete inapplicable) If yes, please explain whether you have made the institution aware of this or why you have decided not to do so.

    The institutions of Boston Children's Hospital (SIMpeds Program (http://simpeds.org) in Boston , USA and The Royal Brompton and Harefield NHS Foundation Trust Hospital (SPRinT (http://sprintsimulation.co.uk) in London, UK will be named as will the two District Health Boards in Auckland and Christchurch. The individuals with responsibility for Paediatric Simulation at these centres are fully aware of this research.

31. Where will the project be conducted? It is recommended that interviews be conducted in public spaces, not in private homes. *The committee appreciates that in some cases there may be good academic reasons for conducting research in private homes. If you believe this applies to your project, we ask you to provide (a) a concise justification of why research in the home is necessary for your project, what alternative locations were considered, and why they were discounted, and (b) detail how you anticipate and will seek to mitigate potential risks to both participants and researchers when undertaking research in a private home(s).*

    Please note: in the case of research involving children, young adults and participants who need particular care, an adult other than the researcher is required to be present.

    The literature review will be conducted in my own time using the library resources available at the University of Canterbury and the University of Otago (one of my employers) and most of the written work is likely to be undertaken within my University Office. I have arranged three visits as detailed below and all interviews will be conducted within the hospitals visited:

    - **Boston Children's Hospital – 8th-13th February 2015-02-24**
    - **Starship Hospital Auckland – 16-18th March 2016**
    - **Royal Brompton Hospital – 21st April**

Risk

If the answer to any of the following questions is "Yes", please indicate briefly the nature of the risk and what actions you could take, or support mechanisms you could rely on, if a participant should become injured, distressed or offended while taking part in this project. In order to maintain a distinction between the researcher and other roles, support should not be undertaken by researcher. At the very least, a list of support services should be included in the information sheet and also participants made aware of the possibility in the information sheet.

32. Is there any risk to physical well-being? **NO** (delete inapplicable) If yes, describe processes in place to mitigate this/these risk(s).

33. Could participation involve mental stress or emotional distress? **NO** (delete inapplicable) If yes, describe processes in place to mitigate this/these risk(s).

34. Is there a possibility of causing moral or cultural offence, inadvertently or otherwise? **NO** (delete inapplicable) If yes, describe processes in place to reduce the possibility of causing such offence, and any consultation/awareness training undertaken.

35. Is deception involved at any stage of the project? **NO** (delete inapplicable) (delete inapplicable) If yes, please describe the deception, justify its use.

    Please note: the HEC considers the use of title in the documents for the participants that is designed to hide the real aim of the project, a deception however mild.

    Please attach the debriefing sheet or script that you will use to debrief each participant after they have participated in the project or at the end of the project itself. Ensure that the debriefing sheet includes an explicit reminder that the participant can withdraw without penalty given the deception involved.

If yes, please describe the deception, justify its use and attach the debriefing sheet or script that you will use to debrief each participant after they have participated in the project or at the end of the project itself. Please ensure that the debriefing sheet includes an explicit reminder that the participant can withdraw without penalty given the deception involved. The use in the information sheet or consent form or questionnaire of a title that differs from the project title given in this application form, in order not to reveal the real aim of the project, is considered to be a form of deception however mild.

Data Storage and Future use

36. Please provide details of how the data will be securely stored, and how you will separate identifying and non-identifying data. ie, What steps will be taken to ensure that information given by participants is safe and protected? All storage facilities including electronic equipment should be in rooms that can be locked. All data should be stored in password-protected files and, where on computers, the computers should be password protected. Data should be backed up or stored on the University servers. If you intend to store the data in cloud services please provide a justification and documentary proof that the data will be secure (eg, relevant sections of the terms of service of the provider).

    The data will be stored under password control on my own personal computer. As mentioned above no personal data will be collected and most of the information is already likely to be within the public domain.

37. Who, apart from the researcher and their supervisor (where applicable) will have authorised access to the data? Research Assistants and transcribers need their own confidentiality forms and their participation needs to be made known to participants.

    No-one

38. What will happen to the raw data at the end of the project? Standard HEC principles are that data from research projects will be kept safely and then destroyed as follows:

At the completion of an Honours or similar project
After 5 years for an MA
After 10 years for a PhD or staff research

Please discuss and justify any variations to these guidelines that your project requires (for instance, if the data is to be kept permanently).

This information should be contained in all information sheets and consent forms.

The data will be stored for the recommended time period as above.

39. What plans do you have for the publication of the data? Please note, and include in your information sheets, that Masters thesis and PhDs are public documents available via the UC library database. Also, participants should be offered summary of results.

The research will be written up as a dissertation for the University of Canterbury, as a short summary report for the CDHB and if appropriate as an article for a peer reviewed publication with full acknowledgement of the host centres and their contribution including permission and possible co-authoring as appropriate .

40. Please describe plans for future use of the data beyond those already described above.

The data are intended to develop my own knowledge and expertise in the evidence available for Postgraduate In Situ Simulation focusing on Crisis Resource Management and Team Training in Acute Care Paediatrics. This information will be shared with CDHB colleagues to facilitate the further development of our simulation program.

Appendix vi

HUMAN ETHICS COMMITTEE

Secretary, Lynda Griffioen
Email: human-ethics@canterbury.ac.nz

Ref: HEC 2015/04/LR

26 March 2015

Maggie Meeks
School of Health Sciences
UNIVERSITY OF CANTERBURY

Dear Maggie

Thank you for forwarding your Human Ethics Committee Low Risk application for your research proposal "Postgraduate in situ simulation within a hospital setting with a focus on crisis resource management and team training in acute care paediatrics: where are we and where should we be?".

I am pleased to advise that this application has been reviewed and I confirm support of the Department's approval for this project.

Please note that this approval is subject to the incorporation of the amendments you have provided in your email of 23 March 2015.

With best wishes for your project.

Yours sincerely

Lindsey MacDonald
Chair, Human Ethics Committee

University of Canterbury Private Bag 4800, Christchurch 8140, New Zealand. **www.canterbury.ac.nz**

Appendix vii
Boston NICU CRM Course Outline

Time	Topic	Instructor	Location	Notes
7.45-7.55 am	**Introductions** Breakfast, consent forms		GPU Conf Rm	Meet the team. Introduction strategy. Establish trust; rapport. Stat1 personal goal from this program today
7.55-8.20 am	**CRM Didactic:** **Review of CRM principles**		GPU Conf Rm	Review 5 CRM Principles with Focus Group Discussion and a few slides. Leadership / Role Clarity Effective communication Equipment Personnel Resources / Chain of Command Global perspective Review of patient information for scenario
8.20-8.40 am	**Scenario Phase 1** Premie with NEC perforation and deterioration		UB Sim	Resuscitation
8.40-9.00 am	**Debrief Phase 1**		GPU Conf Rm	Reactions: How did it feel to be in that scenario? Understanding: • Explore topic through Advocacy / Inquiry • Generalise – has anyone else ever felt that way? • Apply – what concepts can you do in that situation • Summary: Review key concepts learned
9.00-9.10 am	**BREAK**			
9.10-9.40 am	**Didactic** **Delivery of Difficult Information** Video: The WRONG way to give information to parents?		GPU Conf Rm	USE WHITE BOARD for discussion @ what was wrong with this video Review Slides: 1. Why can delivery of difficult news be difficult 2. What parents want from you the clinician 3. ABCDE model for delivery of difficult information 4. Your personal needs 5. Difficult information Tool Box UPDATE: # hours have passes, surgery placed drain only, too unstable to go to OR. Remember to update Actors and Technician for plan for next scenario Scenario will vary depending on RN staff experience level.

9.40-10.00am	**Scenario Part II**: Parent Conference		UB Sim	Discussion regarding infant death using toolkit / ABCDE model. Parents are removed from bed side to confirm for discussion. Questions from parents (actors). What will that look like? Can family be present? Will she be in pain? Can we donate organs?
10.00-10.40 am	**GPU Conf Rm**			Reactions: How did it feel to be in that scenario? Understanding: • Explore topic through Advocacy / Inquiry • Generalise – has anyone else ever felt that way? • Apply – what concepts can you do in that situation Summary: Review key concepts learned *Actors are not present for debrief PERCS facilitator will assist in debrief NEOB slide with discussion
10.40 – 11.10 am	**Scenario Part III**		Conf Rm	Parents (Actors) make decision to withdraw support. Parents ask for private time
11.10-11.50 am	**Debrief Scenario III**			Reactions: How did it feel to be in that scenario? Understanding: • Explore topic through Advocacy / Inquiry • Generalise – has anyone else ever felt that way? • Apply – what concepts can you do in that situation Summary: Review key concepts learned PERCS facilitator and Parent actors present Incorporate feedback from actors in debriefing – how did it feel to be at the bedside during scenario
11.50-12.00 am	**Wrap Up – Course Evaluation**			Picture of whiteboard to send to all participants What one thing did you take away from today? How will this help in your practice at the bedside with families

Appendix viii: NICU CRM Scenario

Scenario Title	2014 NICU CRM Graduate Course: Death in the NICU: Delivering Difficult Information	**Scenario No**	1
Department	NICU 7 North	**Division:**	Newborn Medicine
Learning Objectives	By the end of this session, participants should be able to: Utilize principles of crisis resource management in multidisciplinary care of the NICU infant within the scenarios, transferring knowledge and experience from simulation to practice Recognize individual emotional stressors / perceptions surrounding end of life and available supports during and after death of infant Utilize learned ABCDE model in communication of "bad news" to family Improve the quality of interactions/ communications of the multidisciplinary care team for end of life care given to the family and infant		

Patient Information				
	Name	Baby S C	**Age**	27 5/7th, 9 do
	Dx	necrotizing enterocolitis with concern for perforation. Res Distress, hypotension	**Gender**	female
	Sx	Lethargic, mottled, abd distension, absent resp effort	**Weight**	1250 grams
			Allergies	NKA

Patient History Background	Born 12/2/2013 to a 34 year old G3 P2-3. PNS: A+/ Ab-/ GBS? unremark. Preg comp by PIH. Betamethasone x2, 2nd dose <4 hrs PTD+ MGS04. Delivery by c/s. Apg 5 + 8. Was on CPAP, adv feeds until this am. Noted to be hypotensive/ tachycardic w/ increased A/B's requiring intubation. Noted bldy stool w/oozing rectal bld. KUB w/ pneumotosis + portal air. NPO, vygon LWS, Sepsis eval, IVF, vanco,cefotax + clinda

Simulator(s)		**Monitors**		**Mannequin Props / Set Up:**	
SimNewBie		**EKG**	X	**IV / ART Access:**	PICC line, left femoral - mock up with extension tubing & add bifuse at end PIV
NewBornHal		**NIBP**	X		
AimBaby	X	**SpO2**	X	**Resp Equipment**	Intubated and on Servo-I Intubation equipment with blender 02 Suction/catheters, ETC02 detector Suction for vygon/delee trap - with pea baby food inside - inserts in nose and attaches to suction
PediaSim HPs		**RR**			
PediaSIm ECS		**ETCO2**		**Medications**	Running: Dopamine 5 mcg/kg/minute **Available** Epinephrine 1:10,000 NaHC03 Zosyn, Vancomycin, Cefotaxime, clindamycin
SimMan		**Temp**			
SimMan3G		**ABP**		**Fluids**	Running: DIOW@ 12.5ml / hr hooked up to PICC line Availible :Normal Saline (bolus)
OTHER		**CVP**			
Ingmar ECMO Baby		**ICP**		**Props / Moulage**	Rectal blood - fake blood and jelly Blue discoloration to abdomen - blue paint w/ silver eye shadow - make sure under diaper!
		PAP			

Surfactant Baby	OTHER		OTHER details / Comments
TCG Trainers etc	*RAP* *LAP* *EEG etc*		Stethoscope #6 french vygon catheter Needle aspiration kit: syringe, stop cock, butterfly needle #23 gauge, alcohol, sterile gloves, gauze Gauze in Belly for Distended abdomen Nasal tubing connected to suction cannister (l forget exactly what it is called) Name tag on ICC warmer and ID band on patient Suction cannisters Actor Head set If course in UBSIM, Bring down fake meds from ICUSIM Penrose drain: Will attach between scenario 1 and 2 Cut off finger tip off glove and add green goop inside Place on right side of abdomen

State I	Assessment/Decompensation - Code @ bedside		Scenario Time	20 min
Vitals		Assessment / Details	Expected Interventions	
HR	180	Mottled , abd distended	Volume w/ NS Increase dopamine Consider epi drip Hydrocortisone KUB/CXR Call surgery for penrose/bedside surgery	
BP	38/24 (28)	Absent femoral pulses		
SpO2				
RR				
CVP				
ETCO2				
OTHER				
Controller Notes:			Facilitator Notes:	
Desaturations and brady to 120 then 80 Will stop before infant dies - will then go debrief ATTACH PENROSE DRAIN FOR SCENARIO 2			SIMV 24/6 rate 30 40-100%	
State 2	Scenario 2 after debriefing		Scenario Time	20 min
Vitals		Assessment / Details	Expected Interventions	
HR	109		Dopamine @ 20 mg/kg/min Epinephrine drip Blood products	
BP	36/21			
SpO2	84%			
RR				
CVP		Vital signs do not change and participants bring parents to debriefing space in UBSim to deliver information. Will then go debrief in conference room		
ETCO2				
OTHER				
Controller Notes			Facilitator Notes	
Parent actors at bedside with bedside nurse. Will need to hold parent conference away from bedside to deliver information to parents regarding poor prognosis and consideration to remove from life support				

<table>
<tr><th colspan="2">State 3</th><th colspan="2">Scenario 3: Further deterioration and removal from ventilator</th><th>Scenario Time</th><th>20 min</th></tr>
<tr><th colspan="3">Vitals</th><th>Assessment / Details</th><th colspan="2">Expected Interventions</th></tr>
<tr><td>HR</td><td colspan="2">64</td><td>Mottled , abd distended</td><td colspan="2" rowspan="7">Dopamine @ 20mcg/kg/min
Epinephrine drip
Blood products</td></tr>
<tr><td>BP</td><td colspan="2">32/22</td><td>Absent femoral pulses</td></tr>
<tr><td>SpO2</td><td colspan="2">765</td><td></td></tr>
<tr><td>RR</td><td colspan="2"></td><td></td></tr>
<tr><td>CVP</td><td colspan="2"></td><td rowspan="3">Start at bedside again and move to debriefing space in UBSim to deliver information

May or may not remove from ventilator</td></tr>
<tr><td>ETCO2</td><td colspan="2"></td></tr>
<tr><td>OTHER</td><td colspan="2"></td></tr>
<tr><th colspan="4">Controller Notes:</th><th colspan="2">Facilitator Notes:</th></tr>
<tr><td colspan="4">Infant is a few hours older with persistent acidosis and escalating cardiorespiratory support without a chance of recovery
After meeting with parents, will remove infant from ventilator and support family</td><td colspan="2"></td></tr>
<tr><td colspan="4">*Abbreviations defined in Abreviation list where known</td><td colspan="2"></td></tr>
</table>

Appendix ix

Details for 20th April, 2015 SPRinT Course .

Participants-

5 nurses (1 PICU, 4 cardiorespiratory paediatric ward)

4 doctors (1 PICU Fellow, 1 paediatric ward SHO, 1 anaesthetic fellow, 1 cardiology fellow)

Timings of Course-

1500-1510:	Introductions and Icebreaker
1510-1530:	Discussion/teaching around introduction to CRM and how human factors impact our behaviour
1530-1540:	Introduction to simulation environment, mannequin
1540-1545:	Re-iteration of safe learning environment, Intro to scenario
1545-1605:	Simulated Scenario
1605-1650:	Debrief & Summary
1650-1700:	Evaluations

Appendix x

Boston Children's Hospital Publications

1. Pascucci, R. C., P. H. Weinstock, et al. (2014). "Integrating actors into a simulation program: a primer." Simul Healthc 9(2): 120-126.
2. Arriaga, A. F., A. A. Gawande, et al. (2014). "Pilot testing of a model for insurer-driven, large-scale multicenter simulation training for operating room teams." Ann Surg 259(3): 403-410.
3. Allan, C. K., F. Pigula, et al. (2013). "An extracorporeal membrane oxygenation cannulation curriculum featuring a novel integrated skills trainer leads to improved performance among pediatric cardiac surgery trainees." Simul Healthc 8(4): 221-228
4. Weinstock, P. (2012). "Weathering the perfect storm: a deeper look at simulation applied to pediatric critical care." Pediatr Crit Care Med 13(2): 226-227.
5. Volk, M. S., J. Ward, et al. (2011). "Using medical simulation to teach crisis resource management and decision-making skills to otolaryngology housestaff." Otolaryngol Head Neck Surg 145(1): 35-42.
6. Heard, L. A., M. E. Fredette, et al. (2011). "Perceptions of simulation-based training in crisis resource management in the endoscopy unit." Gastroenterol Nurs 34(1): 42-48.
7. Bong, C. L., J. R. Lightdale, et al. (2010). "Effects of simulation versus traditional tutorial-based training on physiologic stress levels among clinicians: a pilot study." Simul Healthc 5(5): 272-278.
8. Allan, C. K., R. R. Thiagarajan, et al. (2010). "Simulation-based training delivered directly to the pediatric cardiac intensive care unit engenders preparedness, comfort, and decreased anxiety among multidisciplinary resuscitation teams." J Thorac Cardiovasc Surg 140(3): 646-652.
9. Weinstock, P. H., L. J. Kappus, et al. (2009). "Simulation at the point of care: reduced-cost, in situ training via a mobile cart." Pediatr Crit Care Med 10(2): 176-181.

10. Weinstock, P. H., L. J. Kappus, et al. (2005). "Toward a new paradigm in hospital-based pediatric education: the development of an onsite simulator program." Pediatr Crit Care Med 6(6): 635-641.

Appendix xi

The Royal Brompton Hospital Publications

1. Zimmermann, K., I. B. Holzinger, et al. (2015). "Inter-professional in-situ simulated team and resuscitation training for patient safety: Description and impact of a programmatic approach." BMC Med Educ 15: 189.
2. Atamanyuk, I., O. Ghez, et al. (2014). "Impact of an open-chest extracorporeal membrane oxygenation model for in situ simulated team training: a pilot study." Interact Cardiovasc Thorac Surg 18(1): 17-20; discussion 20.
3. Stocker, M., M. Allen, et al. (2012). "Impact of an embedded simulation team training programme in a paediatric intensive care unit: a prospective, single-centre, longitudinal study." Intensive Care Med 38(1): 99-104.